HANDBOOK

OF

ARTILLERY MATÉRIEL

BY

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LIEUT.-COLONEL ROYAL ARTILLERY

WITH PLATES AND INDEX

SIXTH EDITION

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PREFACE

TO

THE SIXTH EDITION.

This work, which has now reached the sixth edition, is brought up to date with the latest changes in *matériel.* It has been necessary to entirely rearrange the chapters; and much additional matter has been added.

F. C. M.

Woolwich,
1898.

Royal Artillery Regimental Order No. 60 authorises this work to be used as a text-book for Officers R.A. qualifying for promotion in Subject "Artillery."

N.B.—The numbers in brackets thus (5304), *appearing throughout the work, refer to the paragraph in the 'List of Changes in War Matériel' issued monthly with 'Army Orders.'*

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HANDBOOK

OF

ARTILLERY MATÉRIEL.

CHAPTER I.

GENERAL PRINCIPLES OF GUN CONSTRUCTION.

For some years past all ordnance manufactured for the Service have been of steel and breech loading. These modern ordnance, as they are termed, differ considerably from the wrought-iron and steel muzzle-loading pieces which, as regards manufacture, they have entirely superseded.

The great improvements in ballistic power and in range and accuracy in modern guns have been brought about by the employment of more suitable steel in gun construction, and, secondly, by considerably altering the relative proportions of calibre and length of bore. In addition, the change to breech loading rendered practicable the provision of a better system of rifling and the more perfect application of the principle of chambering for the charge in a gun. Other defects, also, that were inherent in a piece loaded at the muzzle were removed by the adoption of breech loading. These advances, however, in gun construction called for the introduction of more suitable forms of gunpowder, without which they would have been of little value; and, more recently, by the use of cordite as the propelling agent, gun ballistics have been still further developed.

In the old type of guns using cubical and granulated black powders, high initial chamber pressures were set up, and sufficiently large charges could not therefore be used without exceeding

safe working pressures, so that whilst pressures were excessive the corresponding muzzle velocities were low. This was chiefly due to a percussive rather than a propelling effect being produced on discharge, in consequence of the form of powder employed. By the introduction, however, of slow and regular-burning prismatic powders, and, more recently, by the use of cordite powder, higher muzzle velocities without exceeding the safe working pressures have been obtained, and the total pressure on the base of the projectile is spread over a longer period, acting, in fact, throughout the shot's entire travel in the bore. The forward pressures thus occurring necessitate, however, the walls of the bore of a gun being strengthened up to the muzzle to a greater extent than formerly, and in order to allow of the whole pressure of gas evolved acting on the shot before leaving the bore the latter had to be lengthened considerably, hence there is a very marked difference between the external appearance of an old and new type piece.

The radical changes in gun designs occurred at the commencement of the era of so-called modern ordnance, but subsequently so many improvements have by degrees arisen that B.L. guns of latest designs differ very materially from those first constructed, and the details of this matter will be referred to in a subsequent chapter.

Improvements in the gun are necessarily accompanied by corresponding ones in gun mountings, and in the ammunition used, and stores in general. This fact, therefore, tends to widen and complicate the subject of war matériel, a large proportion of which comprises ordnance and the stores in connection.

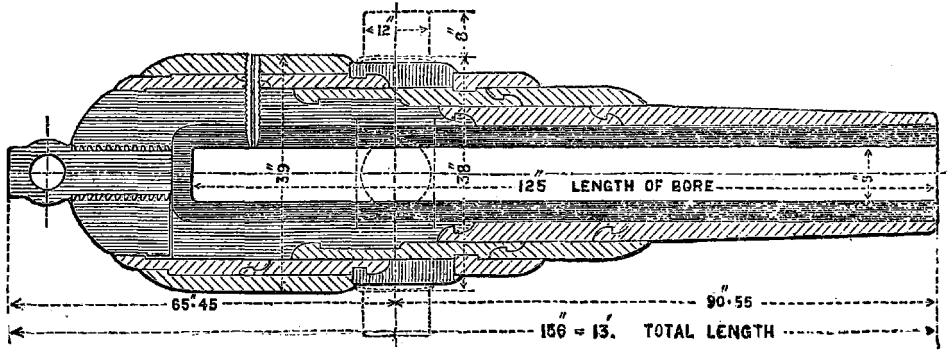
Again, owing to economical and other reasons, long periods will frequently elapse before matériel of a pattern no longer manufactured is finally passed out of the service, and during its obsolescent stage a knowledge of the manufacture and use of the matériel must still be maintained.

As regards the history of ordnance it is briefly as follows. Until about the year 1854 all ordnance were constructed of bronze or iron, and were smooth-bored, these metals being found sufficiently strong, and otherwise suited for the purpose. But the introduction of rifled ordnance necessitated a more tenacious metal being employed, owing to the greatly increased strains occurring on discharge, due to the use of elongated projectiles in a rifled gun to which both a rotary and forward motion had to be imparted, the spherical projectile in a smooth-bored gun experiencing but slight resistance to motion.

Not only were wrought iron, in conjunction with steel, substituted for cast iron or bronze in rifled ordnance, but, in order to gain additional strength, guns were constructed or built up in

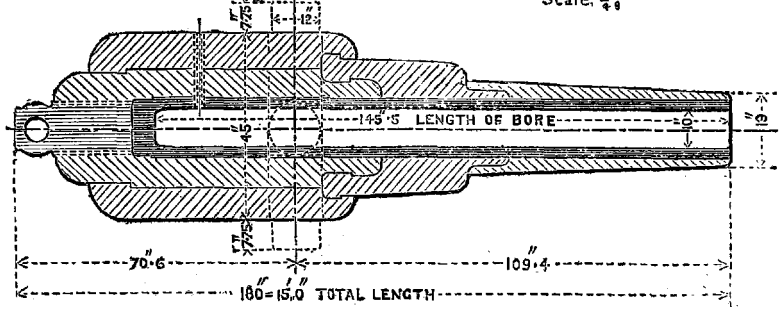
9-INCH. 12 TONS. MARK I.

Scale, $\frac{1}{32}$.



10-INCH. 18 TONS. MARK II.

Scale, $\frac{1}{48}$



layers, with a view to each layer, from the interior to the exterior, bearing a proportionate share of the strain on discharge. In the case of a solid mass of metal in a gun, the inner portion may yield to a pressure from within before the outer part has been subjected to the maximum stress it will bear. Advantage also was taken of the fibrous condition to which soft iron can be brought by rolling and hammering; the fibre being arranged to give the maximum resistance to rupture, and, as regards the gun, being made to run circumferentially to resist the transverse stress, and lengthways over the breech to withstand the longitudinal one set up.

The earliest rifled guns were of *Armstrong Original Construction*, a gun being built up of several small coils of wrought iron, shrunk over an inner barrel of steel, which at first was made of wrought iron also. A forged breech-piece was placed over the breech portion of the gun.

The *Woolwich System* was a modified form of the above, but the coils were fewer in number, and a coil breech-piece was substituted for the more expensive forged one originally employed. In both these systems the breech end of the steel tube was solid, being supported by a cascabel screw inserted through the breech.

Shrinking Process.—By this process an outer layer was expanded by heat to a suitable temperature, and dropped over a tube or inner layer, the latter being kept cool by water and slightly contracted; the result being that on the layers regaining the normal temperature, the outer one remained in a state of tension, the inner being slightly compressed.

The *R.M.L.* built-up guns in the service were constructed for some years on the Woolwich System, their manufacture ceasing about 1880, when the era of modern or B.L. Ordnance commenced. Loading at the breech became a necessity owing to the increased length of bore required in a piece, due to the use of a slow-burning powder, and in addition, as has been said, "chambering," or enlarging of the powder chamber, was difficult of application in a muzzle loader. These and other reasons finally condemned the muzzle-loading system for future manufacture.

The change to steel in the manufacture of ordnance was due to former ideas as to the suitability of the metal for ordnance having undergone considerable modifications. It was found possible to obtain sound castings at a cheaper rate than formerly, and also by the forging process to ensure all imperfections being removed.

The great thickness of metal over the breech compared to that in the forward portion of a gun was found no longer necessary, and, "in order to get an increased ratio of power to weight, thickness of metal at the breech was turned into length at the muzzle."

Metals used in Gun Construction.

Iron.—Iron is or has been used in gun construction in the form of cast iron, wrought iron and steel; these, owing to the very different properties inherent in each, are commonly known as distinct metals.

Cast Iron.—Cast iron is obtained from iron ore by the process of smelting, the molten iron being run off into moulds and termed pig, or cast iron; it contains from two to five per cent. of carbon, the process of smelting having removed the greater portion of other impurities existing in the ore. The carbon may partly exist in an uncombined state as in grey iron, or be perfectly combined as in white iron. Cast iron is hard, but weak and brittle; it has a low melting point, being, therefore, easily moulded as desired; it will not, however, bear forging under a hammer.

Its inherent weakness renders it quite unsuitable for rifled ordnance, but for smooth-bore guns it was inexpensive and a sufficiently strong metal; and these pieces were, for the most part, cast from it.

Wrought Iron.—Wrought, or bar or soft iron, is manufactured from cast iron by the operation of puddling; the object of the process being to remove nearly the whole of the carbon. Puddling is carried out as follows: Pig iron, or cast-iron scrap, after being broken up under a hammer into pieces of a convenient size, are placed in a reverberatory furnace, in which the metal soon melts; it is then stirred, causing the carbon to pass off as carbonic oxide; the iron, which is then in a pasty condition, is collected by the puddler into balls, which are removed and formed into blooms under a steam hammer.

Wrought iron contains not more than about 3 parts per 1000 of carbon. It cannot be melted in any ordinary furnace, but is capable of being heated and hammered or forged to any shape; also by rolling or drawing under a hammer it can be made fibrous, and consequently strong in the direction of the fibre; it is therefore a ductile, malleable and tenacious metal, and can be easily welded—that is, two portions can be heated and hammered together; its limit of elasticity is low, though much higher than in the case of cast iron. Owing to its ductility, it will permanently elongate if subjected to a strain in excess of its elastic limits, but under ordinary circumstances no very violent rupture of the metal can occur as with cast iron or steel. Being soft and liable to defective welds, it was formerly considered a suitable metal for the outer parts of a rifled gun, but not for the barrel.

Steel.—Steel is iron, with an alloy of carbon and manganese. Any iron that is capable of being melted in a furnace in large

quantities, and afterwards forged or rolled out, is steel. Approximately iron can be so treated which contains between 0·2 and 2 per cent. of carbon. Steel is thus a connecting link between cast and wrought iron, possessing the valuable properties of each.

After being cast and forged, steel requires tempering or oil hardening; this process consists in heating the metal to an approved temperature, and then plunging it in oil to cool; it is thus rendered hard and tough, and must be subjected to the further process of "annealing," being reheated and cooled slowly in air, the object being to obtain a sufficiently soft and malleable steel, and to free the metal from internal strains set up in tempering.

As previously mentioned, the A tubes, or inner barrels, were the only parts of a gun formerly of steel. The metal, owing to the hard smooth surface capable of being imparted, was thought specially suitable for the bore of a gun; and, in addition, a steel barrel, if unduly strained, might split, but would seldom stretch permanently, and so deform the bore; whilst the outer layers of the gun, being of fibrous wrought iron, imparted great strength and would, it was thought, in the event of the inner barrel splitting, prevent an accident. Modern improvements, both as regards economy and processes of casting, forging and tempering, have enabled gun steel of a superior quality to be made, and, consequently, the ideas as to its suitability for guns have altogether changed.

Cast steel for ordnance is made by melting in a reverberatory furnace a mixture of hæmatite and Swedish iron and steel scrap. The molten mass is then stirred for several hours, until about 0·29 per cent. of carbon only is present, which is ascertained by testing small samples occasionally. A small portion of manganese and silica are added at the finish to impart toughness to the metal. The latter is then run off into a large ladle and from that into cast-iron moulds. As the ingots thus cast become cool the moulds are easily removed. Specimens of the steel are cut off for testing in order to ascertain the limit of elasticity, point of yielding and breaking strain, both before and after tempering.

Bronze.—Bronze is an alloy of 90 parts of copper and 10 of tin, and that particular kind formerly used for ordnance is known as gun-metal. It is a soft metal and is easily damaged by the projectile in a gun, especially when raised to the temperature caused even by firing a few rounds. Also in the process of casting tin-spots are liable to be formed, owing to the separation of the tin; these, being acted upon by the gases on discharge, soon formed flaws in the bore. Although a tough and tenacious metal it was, for the above reasons, found quite unsuitable for rifled ordnance.

CHAPTER II.

BREECH-LOADING (B.L.) ORDNANCE.

THE general features of B.L. ordnance have been referred to in the previous chapter, and the details of their construction and fittings will now be considered.

CONSTRUCTION.

All natures are built up solely of steel, with the exception of a few of those first manufactured that were made of wrought iron in conjunction with steel coils and hoops shrunk on over a steel tube. Such pieces are: 80-pr. Mark I.; 6-inch Mark II.; 9·2-inch Marks I. and II.; 12-inch Mark I.

A Tube.—To manufacture a tube an ingot of cast steel fixed to the end of a porter-bar is heated and drawn out under the hammer to the rough shape and length required, density and uniformity being imparted to the casting by the operation. Larger tubes are forged out hollow, whilst those for 6-inch and under would be bored out. The operation of trepanning in place of boring is employed when it is desired to remove the inside metal solid for future use. Tubes are made as thin as is compatible with strength, to obtain as far as possible freedom from flaws. In guns of earlier manufacture the breech screw geared into the A tube, which consequently had to be made thicker; subsequently the screw was made to gear into the breech-piece to relieve the strain on the tube. The system adopted at present is described hereafter.

Liners and Alpha-Tubes.—In the later marks of 8-inch B.L. guns and above, a liner or inner tube was inserted in the A tube, the latter being shrunk over an alpha-tube at its muzzle end. The liner extended about two-thirds of the length of the bore from the breech, where scoring and erosion of the bore occurs; it was retained in position by a collar screwed into the breech and by shoulders in the A tube. The alpha-tube extended to the muzzle in continuation of the liner, a collar being screwed in to prevent its forward movement; it also abutted against shoulders in the A tube. Guns having alpha-tubes were not chase-hooped.

Inner A Tubes.—In the most recent designs of guns an inner A tube is driven into the A tube, having its outer surface roughened to prevent any turning movement. It extends from the seat of the obturator to the muzzle, and is secured to the A tube by shoulders for longitudinal strength. A steel breech bush, against which the inner tube bears, is screwed into the breech end of the A tube, the bush also receiving the breech screw. By this method of lining an A tube a gun is capable of fairly easy repair after the bore has become worn by erosion, the lining or inner tube only requiring renewal. The use of a half liner renders the operation of relining a gun easier, but there is a tendency for a slight movement to occur after constant use.

Breech-Pieces, Hoops and Tubes.—These are forged under the hammer from solid or hollow castings, being afterwards turned or, if necessary, bored out to finished dimensions for the shrinking on process. Jackets with trunnions for 5-inch and below are forged out of a single ingot. All the parts used in building up a gun are oil-hardened and annealed, and specimens are cut off each for testing.

Longitudinal Strength.—A method known as the "interrupted projection" principle was adopted some years ago to provide longitudinal strength. It consists in the outer surface of an inner hoop being provided with a ring, which is slotted so as to leave alternate spaces and projections; the inside surface of a corresponding outer hoop being similarly prepared. The outer hoop, expanded by heat, is dropped over the inner one, the projections on the one passing through the spaces on the other; by turning the outer hoop so that the projections on both are in line, the tubes or hoops are interlocked. Steel wedges are then driven into the spaces. By the above system a gun is stiffened at the joints, and well held together longitudinally.

Longitudinal and girder strength is now still further increased by employing a fewer number of long tubes in place of the short hoops formerly used; the parts, in many cases, being shrunk on from the muzzle end of the A tube, on which steps or shoulders are provided to prevent any longitudinal movement.

The layers are also held together by a steel bush screwed into the breech-piece and underlying tube; the bush receiving the breech screw; the 9·2-inch Mark VII., 10-inch Mark III., 13·5-inch Mark III., are constructed in this way.

Circumferential Strength.—The strength required to resist the circumferential strain is obtained by the thickness of the layers surrounding the bore, sufficient metal being employed to provide for strains due to chamber pressures, usually of about 17 or 18 tons on the square inch. The thickness decreases towards the muzzle, where pressures, although sustained, are less.

Wire-Wound System of Construction.

In the construction of certain guns, layers of wire are substituted for those of solid steel, immediately over the A tube; in these cases flat steel ribbon or wire is wound round the barrel in two or more layers, the ends being fastened off by steel rings; the winding tension of the wire requires careful adjustment. A jacket and other tubes, according to the nature of the piece, are then shrunk on in the ordinary way over the wire.

The construction gives good results as regards circumferential strength, but the girder strength is lessened, and for this reason, wire is more suitable for the layers of the breech portion of a gun than for the lengthy part in front of the trunnions.

In the latest marks of 9·2-inch and 12-inch guns, however, layers of wire extend from breech to muzzle immediately over the A tube.

Trunnionless Guns.

12-inch B.L. guns and upwards for sea service are provided with "thrust rings" in place of trunnions, but when issued for land service a trunnion-band with trunnions is fitted. The thrust rings are for the purpose of attaching the gun to the cradle of the hydraulic mounting, and are formed on one of the exterior hoops, and extend round the gun at about the position of its centre of gravity.

In the case of Q.F. guns and B.L. howitzers, longitudinal projections are formed on the sides of the jacket of the piece. These act as guides during recoil in the cradle, the latter forming a portion of the non-recoil mounting employed.

Details of Construction of Marks of each Nature of B.L. Ordnance.

The changes in designs of ordnance due to advances made in gun construction constantly entail the introduction of new Marks of the same nature of gun, and at the same time the ballistics and weight of a new Mark may vary. The following are particulars of each nature and Mark as regards construction.

12-*pr. of* 6 *cwt.*—Mark I. consists of an A tube, with a layer of steel wire over the breech portion; also of a jacket and breech bush; it has an axial "T" vent, the calibre being 3 inches (8051).

12-*pr. of* 7 *cwt.*—Mark I. consists of an A tube, jacket, C hoop

and hood; it has a removable radial steel vent, and its calibre is 3 inches (4877).

15-*pr. of* 7 *cwt.*—This gun is the 12-pr. of 7 cwt. altered as to the vent and sighting; it has a radial "T" vent (8176).

30-*pr. of* 20 *cwt.*—This gun, with a calibre of 4 inches, is for Indian service only.

4-*inch (jointed) of* 25 *cwt.*—This gun is for Indian service only.

4-*inch of* 23 *cwt.*—Mark II. consists of an A tube, into which the breech screw gears; an outer layer of 5 hoops and a hood. Mark III. has a jacket in place of the 5 hoops, into which the breech screw gears; a B hoop and B tube extend to the muzzle; when re-tubed, Mark III. is known as Mark III.A.

Mark IV. comprises an A tube, jacket and B tube; the jacket is secured to the A tube by interrupted projections, and by a steel bush screwed in at the breech; the breech screw gears into the bush. Mark V. is chase-hooped to the muzzle with 3 hoops. Mark VI. has fewer parts, the B tube extending to the muzzle. Marks IV., V. and VI. weigh 26 cwt.

5-*inch of* 38 *and* 40 *cwt.*—Mark II. is similar in construction to 4-inch Mark III., and Mark III. to 4-inch Mark IV. (5548).

Mark IV. is chase-hooped with 5 hoops. Mark V. has a B tube extending to the muzzle. Mark II. weighs 38 cwt., the other Marks 40 cwt. (5549).

80-*pr. of* 80 *cwt.*—This gun is of Elswick construction of an old date. Wrought-iron coils are shrunk over the breech portion of the A tube, and the latter is chase-hooped to the muzzle. The E.O.C. section of groove and the cup system of obturation are employed (4064–5).

6-*inch of* 5 *tons.*—Mark II. is used for drill purposes only, and is of steel and wrought iron. Mark III. consists of an A tube with breech-piece and 1 C hoop, interlocked by a trunnion ring: it has an outer layer of 3 C hoops, and is chase-hooped with 6 B hoops.

Mark IV. has a jacket with trunnions in place of the C layer of hoops, and 3 chase-hoops (5367).

Mark V. is of Elswick construction, having a breech-piece and B layer extending to the muzzle; a third layer is formed by a jacket, with trunnion ring and 1 C hoop. Mark VI. is similar to Mark IV., except that 2 B tube extends to the muzzle in place of 3 chase-hoops (5535).

8-*inch of* 12, 14 *and* 15 *tons.*—Marks I., II. and V. are not now in the Service. Mark III. comprises an A tube, with a breech-piece and trunnion ring interlocking, four hoops form a third layer over the breech-piece, it is chase-hooped to the muzzle, the weight being 14 tons. Mark IV. is of very similar construction, weight 15 tons (5789).

Mark VI. is of Elswick construction, having a jacket over the breech-piece in place of hoops, and a 2 B tube extending to the muzzle; its weight is 14 tons (6277).

Mark VII. is similar to Mark VI., excepting that a jacket and trunnion ring of wrought iron form a third layer over the breech-piece; the E.O.C. section of groove and the cup system of obturation are employed; weight 12 tons (5331).

9·2-*inch of* 21 *to* 25 *Tons.*—Marks I., I.C., I.U.C. and II., have the A tube fitted with a half liner, the breech screw gearing into the A tube. The B layer consists of a coiled iron breech-piece and 1 and 2 B coils of steel; four hoops of steel, extending to the muzzle, support the A tube: the third layer consists of a wrought-iron coil with trunnions forged to it. A bronze sheath serves to balance the muzzle preponderance. A projecting carrier for the breech-piece is used. In Mark I.C. a controlled gear for land service is fitted, Mark I.U.C. not being so fitted. Mark I. weighs 22 and Mark II. 21 tons (5244–5).

Mark III. is of steel entirely, comprising an A tube with breech-piece and hoops extending to the muzzle; a jacket interlocks with the breech-piece, the breech screw gearing into the latter; its weight is 24 tons (5246).

Mark IV. is similar, but the A tube is lined; the weight is 23 tons (5270).

Mark V. is also similar, but there being a liner and an alpha-tube the gun is not chase-hooped; its weight is 22 tons (5660).

Mark VI. Over the A tube of this mark there are shrunk 1 B and 2 B tubes, extending to the muzzle; the breech-piece overlaps 1 B tube and receives the breech screw; the jacket is shrunk over and interlocks with the breech-piece; its weight is 22 tons (6492).

Mark VII. In this gun the parts are shrunk on from the muzzle end to suit the shoulders or steps provided for longitudinal strength; there are four layers of metal, 1 C hoop being additional between the breech-piece and jacket; the layers being thinner are less likely to contain undetected flaws, and there is also a gain in circumferential strength. A bush screwed into the breech secures the breech-piece and 1 C hoop together, the bush receiving the breech screw; a steel ring is also screwed into the jacket and 1 C hoop to secure these together; weight 22 tons (6653).

Mark VIII. is of steel wire construction and similar to the 12-inch Mark VIII.; weight 25 tons (8296).

10-*inch of* 29 *and* 32 *tons.*—Mark I. consists of an A tube over which are shrunk a breech-piece, 1 B tube, 2 B and 3 B hoops, extending to the muzzle; a third layer is formed by the breech-piece and trunnions, which are interlocked to the layer beneath, a

1 C hoop being shrunk on in front of the trunnions; the breech-piece is prolonged at the rear to receive the breech screw; the A tube is provided with a through liner, secured at the breech end by a steel bush screwed into the breech-piece; the weight is 32 tons (5986).

Mark II. consists of an alpha-tube over which is shrunk the A tube, the latter having a liner extending up to the alpha-tube; a steel ring at the muzzle secures the alpha-tube, and a ring screwed into the rear end of the A tube secures the liner; a breech-piece, which receives the breech screw, and a B tube and 1 B hoop form the second layer; over the breech are shrunk and interlocked 1 C hoop and trunnions; 2 C hoop is shrunk on in front of the trunnions and 1 D hoop over 1 C hoop at the breech; weight 29 tons (5987).

Mark III. differs from II. in having 1 B and 2 B tubes shrunk on over the A tube from the front of the chamber to the muzzle; a breech-piece, partially overlapping 1 B tube, is then shrunk on, in front of which are the C tube and 2 C hoop; over the breech-piece and a portion of C tube are shrunk and interlocked 1 C hoop and trunnions; there is 1 D hoop over a 1 C hoop and 2 D hoop over the C tube in front of the trunnions; weight 29 tons (5988).

Mark IV. differs from III. in having a breech-piece, B hoop and B tube shrunk over the A tube, extending to the muzzle; over the breech-piece is a 1 C hoop, and a 2 C and a 3 C hoop are shrunk on over B hoop and B tube; a jacket is shrunk over 1 C hoop, and the trunnions extend over portions of 1 C and 2 C hoops, being interlocked to them, a D hoop being in front of the trunnions; a steel bush is screwed into the breech-piece and 1 C hoop at their rear ends, the bush receiving the breech screw; weight 29 tons (6491).

All the Marks have trunnions for land service.

12-inch of 45, 46 *and* 47 *tons.*—Mark I. is of steel and wrought iron, similar in construction to the 9·2-inch Mark I.; weight 47 tons (4891).

Mark II. is not now in the Service.

Mark III. has three layers of hoops over the breech-piece, one extending to the muzzle; the hoops are short and numerous; weight 45 tons (4925).

Mark IV. has a breech-piece and B tube over the A tube, extending to the muzzle; there are two layers over the breech-piece; thrust rings are provided; the weight is 45 tons (4926).

Mark V. consists of an alpha-tube over which is shrunk the A tube, a steel ring securing the alpha-tube at the muzzle; a liner extends from the seat of the obturator to the alpha-tube, being secured by a bush screwed into the A tube; a breech-piece and

B tube are shrunk on over the A tube and two layers of hoops over the breech-piece, secured by interlocking; thrust rings in place of trunnions are provided; weight 45 tons (6012).

Mark VI. is similar in construction to Mark V., excepting that a chamber and bore liner are used, extending to the alpha-tube, and being for land service it has trunnions; weight 46 tons (6459).

Mark VII. is for land service and has trunnions; over the A tube are shrunk a breech-piece, B hoop and B tube, extending to the muzzle; a C hoop is in front of the breech-piece and a 1 D hoop over a part of the breech-piece and C hoop, secured longitudinally by interlocking; in front and rear of 1 D hoop are 3 D and 2 D hoops; the trunnion is shrunk over parts of 1 D and 2 D hoops, interlocking with them; an F ring for retaining the wedges of the interlocking joints is shrunk in front of the trunnions; the weight is 46 tons (6460).

Mark VIII. is of steel wire construction; the A tube has an inner A tube extending from the seat of the obturator to the muzzle, constituting a liner which can be readily replaced; the inner tube is secured to the outer one by shoulders and by a steel bush screwed into the latter; the breech screw gears into the bush; layers of steel wire over the A tube extend from breech to muzzle, over which are shrunk a jacket and B tube with a C hoop screwed over their junction; thrust rings are formed on the exterior of C hoop; shoulders or steps for longitudinal strength are formed on the interior of the jacket and B tube, and the jacket is further secured longitudinally by a collar screwed into its rear end; the weight is 46 tons (8296).

13·5-*inch of* 67 *and* 69 *tons.*—Mark I. is of old construction; the A tube is lined; the weight is 69 tons (6353).

Mark II. is similar, but has a liner and an alpha-tube, and is therefore not chase-hooped; its weight is 67 tons (6354).

Mark III. is of similar construction to the 12-inch Mark VII. gun; its weight is 67 tons. Mark III.F. has a trunnion band fitted for land service; the breech screw is not fitted with a rack for withdrawal (6355).

Mark IV. is of more recent construction, similar to the 9·2-inch Mark VII. gun; its weight is 67 tons (6652).

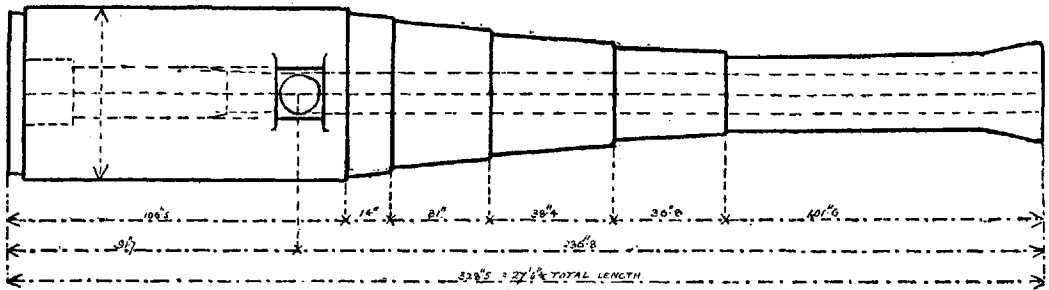
These pieces have thrust rings for sea service.

16·25-*inch of* 111 *tons.*—This gun is of Elswick construction, and consists of an A tube, breech-piece and seventeen hoops, extending from breech to muzzle; the breech-piece is prolonged at the rear to receive the breech screw; three layers, comprising twenty-six hoops, are shrunk over the breech-piece and adjoining hoops, being secured longitudinally by shoulders; thrust rings

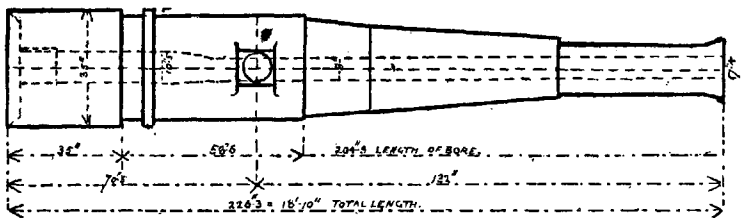
PLATE III.

[To face p. 12.

12-INCH B.L.GUN of 45 TONS. MARK III.

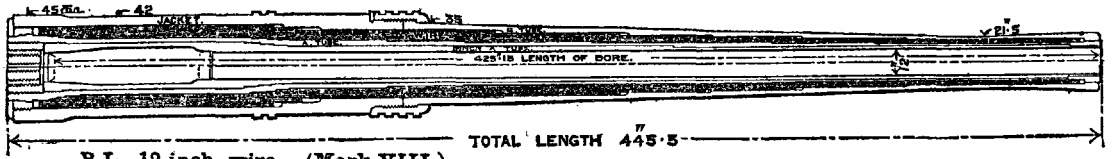


8-INCH B.L.GUN of 13 TONS MARK III.



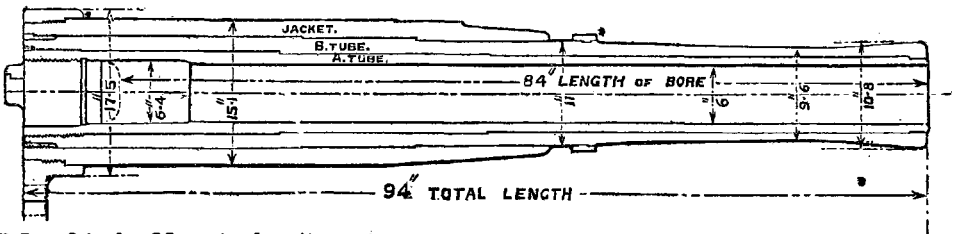
SCALE 1/60

Scale $\frac{1}{20}$.



B.L., 12-inch, wire. (Mark VIII.)

Scale $\frac{1}{20}$.



B.L., 6-inch, 30 cwt., howitzer. (I.)

Scale $\frac{1}{12}$.

B.L., 12-pr., 6-cwt. (Mark I.)

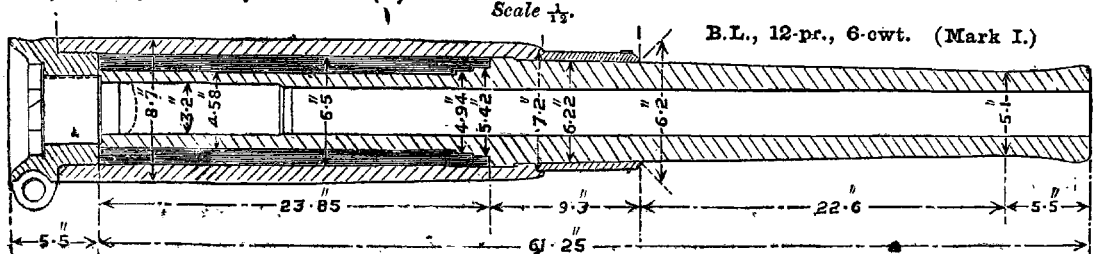


PLATE II.

[*To face p.* 12.

[*To face page* 12.

TABLE I.—B.L. ORDNANCE.

Guns.	Mark.	Service: Land, Naval, or Common.	Nominal Weight.	Length of Bore in Calibres.	Total Length in Inches.	Muzzle Velocity. Foot Seconds.	Penetration of Wrought Iron at 1000 yards.	List of Changes. W. M.	Remarks.
12-pr. of 6 cwt.	I.	L.	6 cwt.	19⅔	66·75	1553	..	8051	Wire construction.
12-pr. of 7 cwt.	I.	L.	7 „	28	92·35	1574	..	4877	
15-pr.	I.	L.	7 „	28	92·35	1574	..	8076	
4-inch	II., II.P., III.	N.	23 „	27	120	1900	5·4 inches	4688, 4878	P. is converted to percussion firing.
„	III.A. and IV.	N.	26 „	27	120	1900	5·4 „	7373, 5546	
„	V. and VI.	C.	26 „	27	120	1900	5·4 „	5547, 6321	
5-inch	II.	N.	38 „	25·07	139·5	1750	6·25 „	4879	
„	III., IV. and V.	C.	40 „	25	139·5	1750	6·25 „	5548–9, 6281	
6-inch	III.	N.	89 cwt. / 5 tons	25·53	153·2	1672	8·8 „	4757 / 5366	Heavier gun is chase hooped.
„	IV. and VI.	C.	5 „	26	173·5	1960 / 1870	10·5 / 9·8 „	5367 / 6278	
„	V.	L.	5 „	30·58	195·3	1920	10·2 „	5535	
6-inch, 80-pr.	..	N.	82 cwt.	25·53	162·6	1575	8·5 „	5510	
8-inch	III.	N.	14 tons	25·1	222·5	1953	13·4 „	4893	
„	IV.	N.	15 „	29·61	254·5	2150	14·9 „	5789	
„	VI.	N.	14 „	29·61	254·5	2150	14·9 „	6277	
„	VII.	L.	12 „	25·5	218·5	2000	12·8 „	5331	
9·2-inch ..	L., I.C., I.U.C. and II.	C. / N.	22 „ / 21 „	25·56	255·8	1781	15·9 „	5244-5 / 6356, 7372	
„ ..	III. and V.	N.	24 & 22 tons	31·5	310	2065	18·8 „	5246, 5660	
„ ..	IV.C. & IV.U.C.	L.	23 tons	31·5	310	2065	18·8 „	5719–20	
„ ..	VI. and VI.A.	C.						6492	
„ ..	VI.B.	L.	22 tons	31·5	310	2035	18·8 „	6425	
„ ..	VI.C.	C.						6712	
„ ..	VII.	N.						6653	
10-inch	I.	L.	32 tons	31·75	342·4	2040	20·7 „	5986	
„	II., III.	C.	29 „	32	342·4	2040	20·7 „	5987–8	
„	III.A., IV.	N. and C.	29 & 26 tons	32	342·4	2040	20·7 „	6848, 6491	
12-inch	I. and IA.	L.	43 tons	25·14	328·5	1914	20·4 „	4891	
„	III., IV.,	L., N.	45 „	25·25	328·5	1914	20·4 „	4925–6	
„	V., V.w.	N., N.	45 „	25·25	328 5	1914	20·4 „	6012-3	
„	VI. and VII.	L.	46 „	25·25	328 5	1914	20·4 „	6459–60	
„	VIII.	N.	46 „	35·43	445·5	2367	28·6 „	8296	Wire gun.
13·5-inch ..	I.	N.	69 „	30	433	2016	28·2 „		
„ ..	II., IIA., III., and III.A. to F. IV.	N.	67 „	30	433	2016	28·2 „	6353-4-5, and 6652	III.F. for L.S.
16·25-inch ..	I.	N.	111 „	30	524	2087	32 „	5511	
Howitzers:									
5-inch	I.	L.	9 cwt.	8·4	49	782	..	8219	
5·4-inch ..	I.	Indian.	12¾ „	10	62	781	..	..	
6-inch	I.	do.	25 „	12	82	777	..	..	
„	I.	L.	30 „	14	94	779	..	9001	
8-inch	I.	L.	70 „	..	..	..	..	..	

formed on the exterior layer. In a newer design of this gun the hoops are longer and fewer in number, consequently more girder strength is obtained (5511).

Construction of B.L. Howitzers.

The following are the B.L. howitzers in use in the service:

5-inch of 9 cwt.; 5·4-inch of 13 cwt.; 6-inch of 25 cwt.; 6-inch of 30 cwt.; 8-inch of 80 cwt.

The 5·4-inch and 6-inch of 25 cwt. are exclusively for Indian service.

5-inch and 6-inch.—The 5-inch consists of an A tube with B tube shrunk on from the muzzle end, extending from breech to muzzle; over the breech portion of B tube a jacket is shrunk on; a steel breech-bush secures the jacket and B tube together; the bush receives the breech screw and abuts against the rear of the A tube for the support of the latter (8219).

Projections on the sides of the jacket form guides for the howitzer in the cradle of the carriage, the piece is therefore without trunnions. A breech-ring is shrunk over the jacket, to which the piston-rods of the buffers of the mounting are attached.

The 6-inch, of 30 cwt., is of similar construction (9001).

Details of Breech Mechanism of B.L. Ordnance.

Breech Screw.—In B.L. ordnance the breech is closed by a parallel breech screw, in which longitudinal portions of the thread are removed, thus leaving three to six smooth surfaces, each one-sixth to one-twelfth of the circumference; the remainder of the thread being left in relief. The interior of the breech, into which the breech screw gears, is prepared in a similar manner. Thus, when the raised portion of the thread of the breech screw is opposite the smooth part of the screw thread in the gun, the breech screw can be either pushed home readily or withdrawn, a turn of one-sixth to one-twelfth being sufficient to engage or disengage the thread of the interrupted screw.

Cam Lever.—The breech screw is locked and unlocked by means of the cam lever hinged to it. A recess in the carrier ring receives the cam when the lever is turned down, which locks the breech and prevents any movement. After unlocking the breech, the cam, when the lever is lowered, presses against the carrier ring and partially withdraws the breech screw, thus preventing any liability to jam.

Obturating Pad.—In order to seal the escape of gas at the breech an obturating pad is provided for B.L. ordnance, with the exception of a few constructed in the early days at Elswick. The principle is as follows: a steel spindle, forming the axial vent, passes through the breech screw, having on its front end a mushroom-shaped head; between the mushroom and the screw is placed on the spindle an annular obturating pad of asbestos covered with canvas, the pad being enclosed between protecting discs of tin and steel adjusting discs, the whole being free to revolve in the breech screw. On firing, the mushroom-head is pressed back against the asbestos pad, which is squeezed against the end of the walls of the chamber; being soft and slightly elastic, the pad readily accommodates itself to any slight irregularity, such as grit, &c., and can be easily renewed when necessary. When once a pad has been permanently expanded at proof or by firing with a full charge, it provides a most satisfactory gas-sealing arrangement. Spare obturating pads are kept under pressure in wooden boxes, being nutted up between discs of wood.

Cup Obturator (Elswick System).—80-pr. 6-inch Mark V. and 8-inch Mark VII. guns have a steel cup obturator; the cup is attached to the face of the breech screw by a spindle passing through the breech screw; its back is flat, whilst the face of the breech screw is slightly rounded; on firing, the cup is pressed against the breech screw, and its rim is driven against a copper ring let into the walls of the bore. The disadvantage is that the cup and ring require frequent renewal, which, in the case of the ring, is a work of some hours.

Vents for B.L. Ordnance.

Axial Vent.—In B.L. ordnance, except field, the spindle passing through the breech screw is drilled longitudinally, with a vent channel for the passage of the flash from the tube on firing. This axial vent, or spindle, is secured to the breech screw at its outer end by projecting rings gearing into a slide-box in two parts in which the firing lock slides; in the heavier pieces a nut and spring are fitted to assist the attachment.

"*T*" *Vents.*—With 15-pr. guns a radial "T" vent is used; it consists of two parts of steel, and passes through a hole cut through the walls of the bore; it is secured in the bore of the gun by a screwed head, with a copper washer; an axial "T" vent is used with the 12-pr. of 6 cwt. gun and B.L. howitzers, the vent head in this case being screwed to the ordinary axial vent; the T friction tube is used with "T" vents, radial or axial.

Firing Mechanism.

Means of Firing.—Percussion and electric firing are used with B.L. ordnance except with 12 and 15-pr. guns and howitzers, in which the frictional method is employed.

Locks for Firing.—4-inch to 6-inch guns are provided with percussion locks only; 8-inch to 12-inch with both percussion and electric locks; 13·5-inch and 16·25-inch with electric locks only.

Electric Locks.—In the land service the "lock, electric B," is used in 9·2-inch, 10-inch and 12-inch guns, with the V.S. electric P tube, and also "lock, electric C," which is interchangeable with the B lock, and is used with the V.S. electric wireless P tube.

Somewhat different patterns of electric locks are used with 8-inch, 13·5-inch and 16·25-inch guns.

The breech mechanism and locks of guns are so arranged that when the screw is home and the cam lever lowered electric contact is made, and the gun can only be fired when such is the case.

Lock, Electric B.—This lock consists of a steel frame sliding in the slide-box; it has a projecting arm with an insulated contact, to which one of the wires of the tube is attached, the other wire being fixed to a terminal going to earth; the frame of the lock has a guide-bolt engaging with a link in the cam lever; by depressing the latter the lock is made to slide into the firing position, whilst on raising an extractor for the tube is brought into play; a bracket with a contact is fixed to the bronze end frame on the gun, to which the line wire is attached; when the breech is properly closed contact is made between the bracket and contact of the arm of the lock.

Lock, Electric C.—This lock is similar to the B lock, except that contact is made with the wireless tube by means of a chisel pointed contact placed in a lever pivoted to the frame of the lock and actuated by a spring, the upper end of the contact being connected to the firing battery; a serrated cutter fixed under the lock encircles the head of the tube, making contact with the connection to earth. Lock, electric C^1, is the B lock converted to C.

Special Electric Locks.—For 13·5-inch guns a "lock, electric wired," is used, somewhat similar to the B lock. Mark I. is for use with V.S. electric P tubes, and Mark II. with wireless tubes. With Mark II. the upper contact of the lock, which is provided with a steel punch point, is forced partially into the head of the wireless tube on firing and contact made. A very similar special lock is provided for 12-inch Mark VIII. guns.

Percussion Locks.—"Lock, percussion D," is used in 9·2, 10

and 12-inch guns, for land service; the lock consists of a frame fitted with a striker, cocking lever and spring guide bolt; it is attached to the cam lever by a sliding link and guide bolt, so that the striker is automatically cocked by the cam lever and retained by the trigger in that position; the latter has two loops for a horizontal or an upward pull; the lock is provided with a tube extractor similar to the electric lock B.

Special Percussion Locks.—Locks on a similar principle are used with 4, 5 and 6-inch guns, and other special patterns for 9·2 and 12-inch guns for sea service.

Carrier Rings, &c.

Carrier rings of steel or bronze are hinged to B.L. ordnance, with the exception of such pieces as are fitted with hydraulic loading gear or those of earliest construction, which have a projecting horizontal carrier. The carrier ring encircles the breech screw, supporting it when open in the loading position. In lower natures of guns the ring is hinged to a hood shrunk on to the breech, but in 9·2-inch guns and upwards a bronze frame screwed to the breech is used for this purpose. A retaining clip holds the carrier ring to the gun whilst the breech screw is being pushed home or withdrawn, and also prevents the screw being drawn out of the ring when in the loading position. There is also a retaining latch which keeps the carrier ring back in the loading position except when controlling gear is used.

Locking and Unlocking the Breech Screw.—For turning the breech screws of 6 and 8-inch guns a 17-inch lengthening lever can be attached to the cam lever for additional power, and in the case of 9·2-inch to 12-inch guns for land service a ratchet lever apparatus is applied to the breech mechanism for the same object.

With certain 9·2-inch and 10-inch guns a controlling gear apparatus is used for pushing home or withdrawing the breech screw, and with 12-inch guns for land service a withdrawing apparatus is attached to the side of the slide. With heavy guns for sea service hydraulic power is used.

Fittings and Implements for B.L. Guns.

Fittings, sighting appurtenances and implements are issued with each gun for service, and the following, which accompany a 12-inch Mark VI. for land service, are given as a guide.

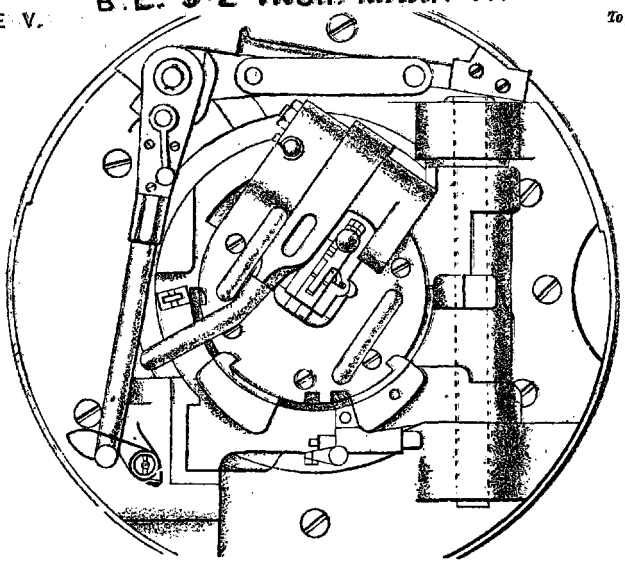
For Breech Mechanism.

Breech screw of steel, with cam lever, one spiral spring and flat spring, and eyebolt preserving screw.

PLATE V.

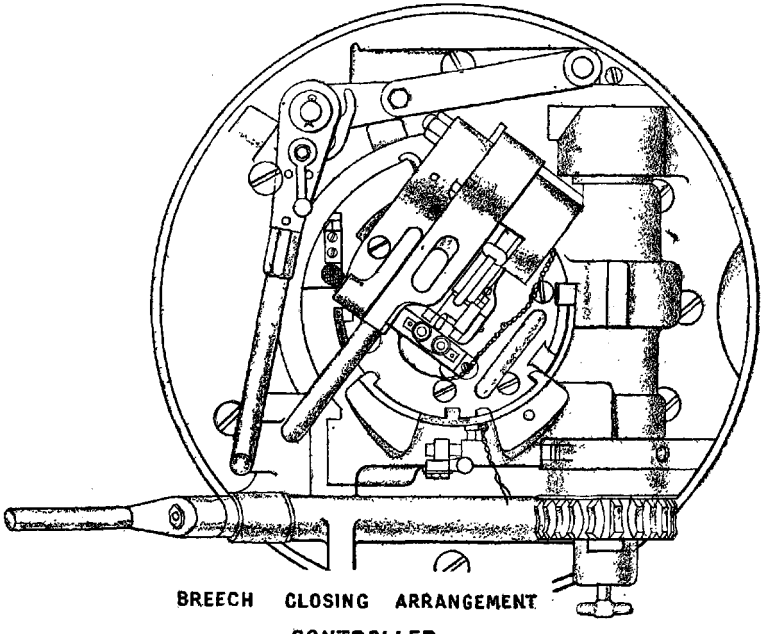
B.L. 9·2 INCH. MARK IV.

To face p. 16.



BREECH CLOSING ARRANGEMENT
UNCONTROLLED.

Scale 1/12



BREECH CLOSING ARRANGEMENT
CONTROLLED.

Axial vent of steel, with spring, nut and washer.
Obturating pad of annular canvas-covered asbestos.
Obturating pad discs—two adjusting discs of steel and one set of tin protecting discs.
Slide box of steel, in two parts.
Ratchet lever for breech screw of steel, for locking and unlocking, with spring, two links and sliding block.
Carrier ring of bronze, with hinge bolt, roller frame and flat spring.
Stop bolt of steel, for breech screw.

For Firing Mechanism.

Lock, electric B, of steel, with two terminals and insulated contact, two spiral springs, extractor and lanyard.
Lock, percussion D, of steel, with striker, trigger and cocking lever, four spiral springs, extractor and lanyard.
Fixed frame electric contact of aluminium bronze, with insulating bush, nut, fixing screw and lead.
Lead cover of bronze, with four fixing screws.
Elevating bracket of bronze, for attaching the elevating gear to the gun, with two studs, two keep-pins, six screws and preserving screws.

For Sighting Arrangements.

Automatic "C" tangent sight clamps of bronze, two in number.
B.L. tangent sights of steel, with removable range strips, two to a set.
B.L. foresights "C" of bronze, two in number.

Implements Issued with the Gun.

36-inch vent bit, of steel, for cleaning the vent when required.
Special "P" extractor, of steel, for tubes.
Axial vent rimer, of bronze.
36-inch vent rod, of steel.
Cartridge tray, of bronze.
Shot tray, of bronze.
Wrenches, three in number.

Attachment of Elevating Gear.

For the attachment of the elevating gear to a B.L. gun a bronze elevating bracket is screwed on to the piece, or an elevating band is shrunk on near the breech of the gun in manufacture, the pattern varying according to the nature of mounting to be employed.

System of Rifling B.L. Ordnance.

System.—In B.L. ordnance the rotation of the projectile is effected by means of a copper driving band attached near its base end, the action on discharge being that the soft copper of the band is compressed into the grooves of the gun, at the same time being cut into by the lands. After a gun has become worn or enlarged by constant firing it may cease to rotate its projectiles satisfactorily, and it then becomes necessary to attach augmenting strips of copper to the band to increase the diameter of the band and so restore the shooting of the gun.

Grooves.—The systems of rifling adopted in B.L. ordnance are, the polygroove, or hook section, and the plain, or modified plain. In a few cases also the polygroove of Elswick section is employed. The non-driving side of the groove of the hook section is sloped off to the surface of the bore or land, the depth of the groove being, 0·04 inch for field, 0·05 inch up to 9·2-inch guns, and 0·06 inch for heavier natures, the width varying with the size of the piece. The number of grooves in a gun correspond to about four times the number of inches of calibre. Thus a 12-inch gun has forty-eight grooves, but 12-pr. and 4-inch guns of new manufacture, or when re-tubed or through-lined, have six grooves for each inch of calibre.

Twist of Rifling.—In Mark I. system of rifling the angle of twist varies with each nature or Mark of gun. It is increasing up to a certain distance from the muzzle, and after that uniform.

In Mark II. system the angle of twist, which is the same for all natures, increases from 1 in 60 calibres at the breech to 1 in 30 at the muzzle.

In Mark III. system the groove is straight for a short distance, and after that has an increasing twist from 0 to 1 in 30 calibres at the muzzle.

Mark I. system was until recently employed with all B.L. guns, but was superseded, in the case of 6-inch and upwards, of new manufacture, or when re-tubed or through-lined, by Mark II. Mark III. has now replaced Mark II. for future use, and is known as the "Polygroove, modified plain section."

Powder Chambers of B.L. Ordnance.

Chambering.—The principle of enlarging the diameter of the breech end of the bore of a gun in order to provide a chamber for the charge has been for some time in vogue. By thus increasing the cubic capacity of the space behind the projectile, or, in other

words, "air-spacing" the charge, the initial or chamber pressures are lowered, so that larger charges can be used with a corresponding increase in muzzle velocity. The most suitable charge, as regards weight and nature of powder or size of cordite, in conjunction with the space it is to occupy, must be theoretically and practically ascertained for each nature of gun, in order to obtain the best results as regards muzzle energy and safe working pressures. The size of charge chamber is regulated by its diameter and length, but a large diameter tends to weaken the gun, whilst too long a chamber may set up abnormal pressures, and at any rate entails a longer bore, and consequently a heavier gun. A length of about three to five times its maximum diameter is considered suitable for a charge chamber, this length being about one-fifth or one-sixth of the whole bore. As regards diameter, the 12-pr. of 3-inch bore has a chamber of 3·625 inches, the 16·25-inch gun of 21 inches; diameters of chambers of other natures bearing about the same relative proportion to calibre, but in guns of more recent design the diameter is still further increased. The front end of the chamber is either sloped down to the commencement of the rifling, or made with rounded off steps, which facilitates loading. The rear end is coned down to a smaller diameter in new designs to lessen the pressure on the breech screw. The gravimetric densities of charges, or space the charge occupies, can be most readily compared by dividing the cubic capacity of the chamber in inches by the pounds in the charge, this being 29 in the 16·25-inch B.L., 33 in the 6-inch B.L., 37 in the 17·72-inch M.L., and 30 in the 12·5-inch R.M.L. guns, when using powder. With cordite more air space is allowed for the charge, and the g.m. density is then from 80 to 100. The true definition of gravimetric density is referred to later.

Sights of B.L. Ordnance.

Tangent Sights.—For ordinary use B.L. ordnance are fitted with two tangent or side sights and two foresights, the sockets and holes for the tangent sights being set at an angle of 1° 30′ or 1° 40′ to the left to counteract "drift," due to the right-handed twist of the rifling. The sight bars are of steel, with cross heads, being square in section in the case of 4 and 5-inch guns and triangular in other natures, except that those for 80-pr. and 8-inch Mark VII. guns are rectangular.

The front face of a sight bar is graduated with a scale of degrees corresponding in each case with the radial distance between the tangent and foresight. A rack is also provided on the

front face, gearing with the pinion of a bronze automatic clamp, so that, by means of a mill-headed screw on the latter, the sight bar can be raised and retained at any required height.

The remaining faces of a triangular bar are fitted with removable range strips of aluminium graduated in yards, an additional strip being provided for attachment when required. Scales, however, are permanently engraved on the bars of sights of 12-pr., 15-pr., 4-inch and 5-inch guns.

The cross heads of sights for 6-inch guns and upwards are fitted with a steel deflection leaf with vertical sighting blade, corresponding in height to about 1000 yards of the scale, for use when line only is obtained by the sight. The leaf is also provided with a notch 0·06 inch deep, for use when elevation is given also by the sight; an arrow under the notch indicates the amount of deflection given, up to two degrees, right or left.

Tangent sights for 6-inch B.L. guns and upwards for land service are now made "left" and "right," and are so stamped; the vertical sighting blades on either side are turned inwards when in position in the gun to correspond with the sighting blades of the foresights (8837).

Foresights of B.L. Ordnance.—Foresights of "drop pattern," similar to those for R.M.L. guns, are employed, a drop sight consisting of a pillar and collar of gun-metal, a steel acorn point being screwed into the pillar. The sight is dropped into a gun-metal socket, being secured by a double bayonet joint.

Vertical sighting blades are now provided to foresights to facilitate laying for line, the sights being stamped "left" and "right," the blades being turned inwards when the sights are in position in the gun (8837).

Sights B and Telescopic (II.)—These sights, the invention of Captain Scott, are provided for 12-pr., 15-pr., and 4 and 5-inch guns, in addition to ordinary sights. The sight consists of a telescope pivoted to a frame, resting in bearings on a bracket attached to the right trunnion of the gun. The sight can be used for reverse laying by inverting the telescope, and for employment as a clinometer it is provided with a level.

Howitzer Sights.—Cross-bar sights, on French's system, are used with howitzers on both sides. These are described under R.M.L. howitzer sights.

Speed Sights.—These are for sea service, for use with 4-inch up to 10-inch B.L. guns. The sight bars are of ordinary pattern, but are fitted with longer cross heads. The latter are graduated with a scale for speed of the ship up to thirty knots, and with a deflection scale up to 2°, right and left. The foresights are of the ordinary drop pattern.

Cradle and Carriage Sights.—In the case of guns mounted in a cradle the sights may be on the latter, and in the case of howitzers the carriage may be also provided with sights for use for obtaining the line only.

Instruments for Giving Elevation.

Index Plate and Reader.—For giving elevation a gun-metal index plate is fitted to the right side of the breech of 6-inch B.L. guns and upwards when mounted on sea fronts. The plate is graduated in degrees for elevation and depression, and is provided with a yards scale, corrected for height of axis of the trunnions above mean sea level, the reader being fixed to the bracket of the carriage. Line in this case would be obtained by the sighting blades or by the graduated traversing arc.

Elevation Indicator.—This instrument is used for the same purpose as the above, which it has superseded in modern mountings. It consists of a circular disc attached to the left side of the mounting, and is graduated with a scale of yards corrected for height of trunnions. It gears with the elevating arc of the gun.

Hydro-Clinometer.—The instrument is screwed to the right trunnions of guns on sea fronts, in open or casemated works as ordered. It is graduated with a yards scale, corrected for the height of the axis of trunnions above mean sea level, a column of coloured liquid indicating the required number of yards of elevation.

Clinometer.—A clinometer is issued for use with all ordnance except 12 or 15-pr. guns, which have telescopic sights. The instrument shows the quadrant elevation or depression of the piece. It is adjusted on the clinometer plane cut on the breech of guns. The "Clinometer large Mark I." is issued for garrison, siege or naval service, and the "Clinometer Field Mark II." for other services. The large instrument is graduated to 45 and the Field to 26 degrees.

Markings, Nomenclature and Examination of B.L. Ordnance.

Markings on Ordnance.—On the upper surface of the breech portion of B.L. ordnance the royal monogram, weight, angle of inclination of the sights, and the Broad Arrow are stamped, also a plane surface for the use of a clinometer, except in the case of 12 and 15-pr. guns. The line of horizontal axis is shown on the breech and muzzle, and on the face of the latter vertical and horizontal lines are marked, also the system of rifling used, if Marks II. or III. On the right trunnion the calibre, Mark, weight and

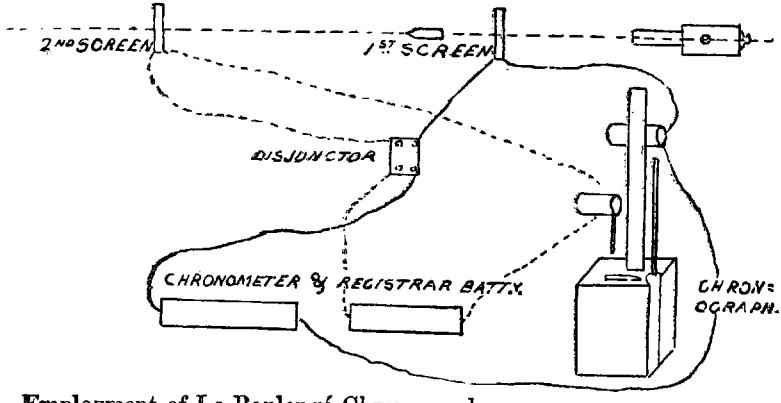
register number of the piece are stamped, and on the left one its Mark and year of proof. For the identification of B.L. guns when dismounted, the right trunnion markings are made in addition on the rear face of the gun, the letter "N" being added if for sea service.

Examination of B.L. Ordnance.—The regulations require ordnance to be examined by a qualified inspector after firing a prescribed series of rounds, viz.: for 12-inch guns and upwards 32 full charges, or the equivalent of reduced; 50 for 8 to 12-inch; 100 for 4 to 8-inch; 150 for guns below 4-inch. The result of the examination is entered on the memorandum of examination, or register sheet of the gun, which contains a diagram and full description of the piece, also a record of the number of rounds it has fired, including proof. Instruments for taking gutta-percha impressions of the bore are used, with bore and chamber-plates suitable for each nature. The breech fittings and other loose parts, and also the exterior surface of a gun, are examined on these occasions.

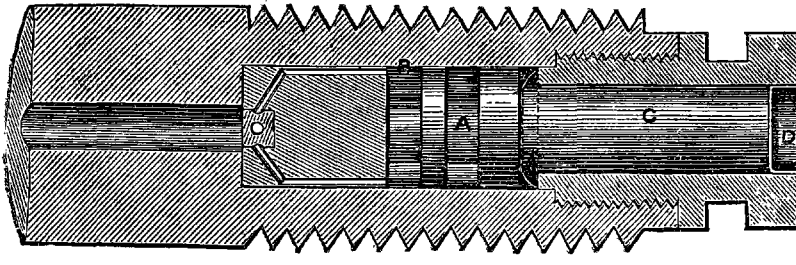
Instruments for Measuring Velocities and Pressures in Bore.

Boulengé's Chronograph.—In order to measure the muzzle velocity of a projectile, Boulengé's chronograph is used, in which electricity is the agent employed. Frames with wire stretched across them in connection with primary circuits are placed so that the shot shall cut the wires successively, thereby interrupting the electric currents which pass through them and the instrument connected with them. The frames are 120 feet apart, and the first screen 30 feet from the muzzle. Then since $\frac{\text{space}}{\text{time}}$ equals the velocity at the middle point, in this case 90 feet from the muzzle, and supposing the time the projectile takes to pass between the screens is found to be 0·1 second, then $\frac{120}{0{\cdot}1}$ equals 1200, so that 1200 foot-seconds would be the velocity of the projectile half-way between the screens, from which the muzzle velocity is calculated.

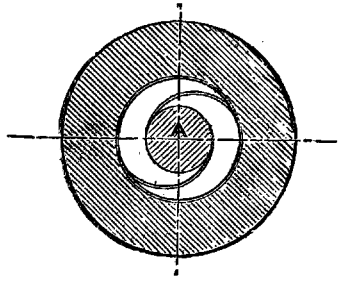
A description of the instrument will be found in the R.G.F. treatise; but briefly it consists of a "chronometer" or long rod which falls when the current which holds it up is broken by the shot passing through the first screen. A second short rod termed the "registrar" falls when the shot passes through the second screen, and breaks the second current; this registrar in falling acts on a lever and trigger which releases a circular



Employment of Le Boulengé Chronograph.



THE CRUSHER GAUGE.



knife, the latter flies forward and marks the chronometer rod, which has a casing of zinc over it. By this mark the interval that elapsed between the interruption of the two currents is ascertained. A graduated rule is used for measuring the height of the indent above the rear mark, and by means of a scale on it the velocity of the projectile can be read off without any calculation.

The Crusher Gauge is used to measure the pressures in the bores of guns. The instrument consists of a steel cylinder, solid at one end, the other end being provided with a screw having a central hole in which fits a steel piston. Inside the chamber there is placed a copper cylinder half an inch in length and $\frac{1}{12}$th of a square inch in sectional area. One end rests against the bottom of the chamber, whilst the other is acted on by the piston. On discharge the copper cylinder is crushed by the piston, and the amount of compression indicates the pressure exerted by the powder gas. Its length after compression is read by means of a micrometer reading to one-thousandth of an inch; and by reference to tabulated results of previous compressions of similar coppers, the pressure in tons on the square inch is given without any calculation. Crusher gauges are used screwed into the bases of projectiles, in which case a record is obtained of the maximum pressure to which the projectile has been subjected; or they may be placed in the rear end of the cartridge, or loose at the end of the bore, to ascertain powder pressure, and so detect any deterioration of powder on service.

The Noble Chronoscope is employed for measuring the velocity at very small intervals along the bore, and hence calculating the pressures in the bore. The precise instants at which a shot passes certain defined points in the bore are registered on a recording surface by means of electric currents. The instrument consists of two parts, the mechanical arrangement for obtaining the necessary uniform speed of the recording surface, and the electrical recording arrangement.

For proof of powder, Boulengé's instrument and the crusher gauge are used.

Factor of Effect.—If the muzzle energy of a gun is compared with the energy which the charge of powder is capable of exerting as a maximum, a great difference will be found in the values; and the "factor of effect" in the case of any particular gun is usually expressed as a percentage of the full effect which the powder charge is capable of producing. In the case of modern B.L. guns the factors are about 70 to 80 per cent. Tables are prepared in all treatises on ordnance or gunnery, in which the maximum work capable of being performed by the charge can be read off, and so the factor of effect can be readily calculated.

CHAPTER III.

QUICK-FIRING GUNS.

General description of Q.F. Guns.—These guns, as regards their employment for land service, are usually mounted on the sea fronts of coast fortresses, for the defence of mine-fields and channels, and for repelling the attacks of torpedo-boats and other small craft. The heavier natures, that is up to 6-*inch calibre*, would also be available against the more vulnerable portions of ships; 3 and 6-pounders in some cases also form part of the light armament of a fortress for general defence, mounted on travelling carriages.

For sea service Q.F. guns are used as a broadside or auxiliary armament, in all classes of vessels, and the lower natures for boat service.

Hitherto, these pieces have not been used by any nation, in field artillery, for which service it is of prime importance to obtain a well-aimed shrapnel fire at long ranges; in the field gun power and mobility cannot be advantageously sacrificed to rapidity of fire. Endeavours, however, are now being made by most of the powers to render the laying and general service of guns in the field more rapid, which can only be done by reducing the recoil of the gun to a minimum. Consequently improvements in the carriage rather than in the gun must be looked for, in the production of a Q.F. gun for field purposes.

Definition of Q.F. Guns.—The class of ordnance known now as quick-firing guns differ from ordinary pieces in their being more rapidly loaded, laid and fired.

Quicker loading is obtained by using a quicker acting breech mechanism; and also by using metallic cases for the charge, and in lighter natures by attaching the projectile also to the case. By the use of a metallic case, sponging and ramming home are rendered unnecessary, also the case provides an efficient obturator, and keeps the gun cool and free from fouling, its disadvantage being a considerable addition to the cost and weight of ammunition. Rapid laying is obtained by employing mountings in which the gun recoils in a cradle, buffers being used, and the piece is pushed

forward again into the firing position by springs. This method is easy of application to a fixed mounting, but it is otherwise with a wheeled carriage.

Natures and Construction of Q.F. Guns.

The natures of Q.F. guns in use in the service are: 6-inch, 4·7-inch, 4-inch, 12-pr., 6-pr. and 3-pr. guns. Their description and construction are as follows:—

Ordnance Q.F. 6-inch Gun, Mark I.—This gun is of steel, and weighs 7 tons. It consists of an A tube, over which are shrunk a breech-piece, prolonged at the rear for the breech screw; a 1 B and 2 B tubes extending to the muzzle; a jacket and C tube. A breech ring is shrunk over the rear of the jacket, to attach the buffers of the mounting, and projections are formed on the C tube to form guides in the cradle in which the gun recoils.

The breech is closed by a steel breech screw, parallel as to its rear portion, and tapered in front, so that it can be swung at once into its loading position; the thread on each portion is interrupted by three longitudinal smooth surfaces, the smooth surfaces on the parallel being opposite the divisions in relief on the tapered part. The breech-piece is prepared in a similar manner; by this means the longitudinal strain is distributed circumferentially.

The cam lever is attached to a bronze plate on the rear end of the breech screw, and a projection engaging in a recess in the cam retains the lever up or down. The carrier supporting the breech screw is hinged to the breech ring, and a spring clip fitted to the carrier retains the screw in position when the breech is open; in closing the breech it is disengaged automatically.

In order to gain momentum for locking and unlocking the screw, a tappet ring is fitted to the outer face of the breech screw; it is capable of moving through a portion of a circle before the screw is started.

Firing mechanism.—For electric firing a striker attached to the carrier passes through the axis of the breech screw, and is provided with a steel needle which makes contact with the electric primer of the cartridge. A wire attached to the other end of the needle striker is connected with an insulated contact fitted to the mounting. On pulling the trigger lever *on the cradle*, contact is made by the end of a lever pivoted to the cradle, the lever contact being connected by cable to the battery.

For percussion firing the electric striker is also used. By raising the cam lever to open the breech, the striker is cocked and retained in position by a trigger with three arms pivoted to the

rear of the carrier. The trigger, which has two loops, is pulled by a lanyard when the cam lever is depressed. The gun can be fired from either side. An extractor for automatically withdrawing empty cases is provided.

A bronze shot tray, hinged to the right side of the breech to facilitate loading, is raised automatically to the loading position.

Rifling.—The polygroove hook section is used for the groove, which has an increasing twist of 1 in 60 to 1 in 30.

Sights are not required for these guns, which are provided with cradle mountings, the cradle having a graduated elevating arc and reader.

6-*inch Q.F. Gun*, Mark II.—This gun is of steel and wire, and weighs 7 tons. It consists of 1 B tube shrunk over the A tube, which is secured longitudinally by shoulders and by a bush screwed in at the breech, the breech screw gearing into the bush. Layers of steel wire are wound round 1 B tube. A B hoop and 2 B tube at the muzzle are then shrunk on, and finally a jacket secured by shoulders and by the breech ring. The latter is shrunk over the steel bush and screwed to the jacket, and has projections for attachment to the mounting.

In other respects the gun is similar to Mark I.

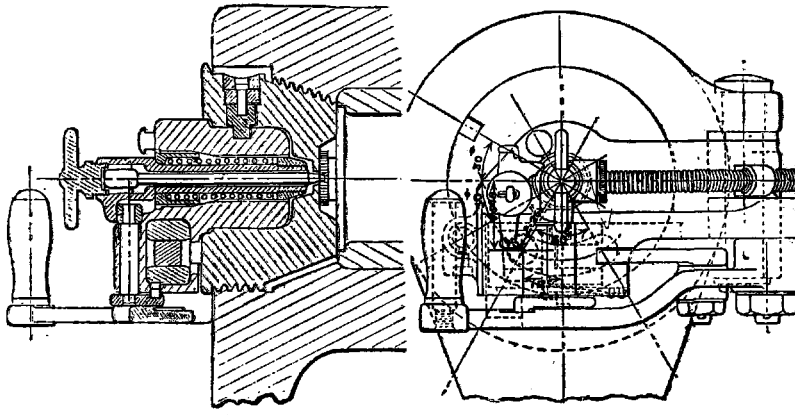
6-*inch Q.F. Gun*, Mark III.—This gun is of steel, and weighs 7 tons. It is similar in construction to Mark I., with the addition of a trunnion hoop with trunnions; it has also an elevating band shrunk round the jacket for the attachment of the elevating gear.

The gun is sighted with ordinary service sights, the bars being triangular in section.

The breech and firing mechanisms are the same as I. and II.

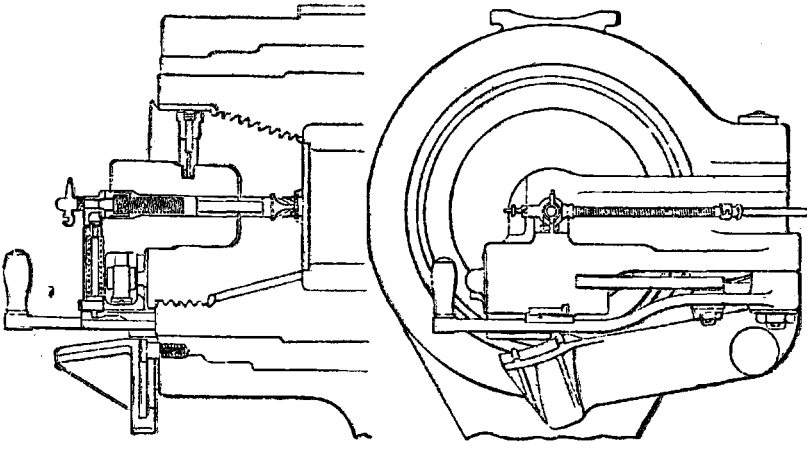
6-*inch Q.F. Gun*, B.—Certain of the above guns, Marks I. to III., have been converted, and are distinguished by the letter B. The conversion consists in fitting the guns with "Single Motion" breech mechanism, no alteration to the guns being required for its adaptation. The breech screw is of the same pattern, and is attached to the carrier by a screw; the carrier has a "breech mechanism" lever, link and sliding block by which the breech screw is worked.

6-*inch Q.F.C. Gun*, Marks $\frac{\text{I.}}{\text{IV. and VI.}}$, $\frac{\text{II.}}{\text{III., IV. and VI.}}$, $\frac{\text{III.}}{\text{III.}}$, $\frac{\text{III.}}{\text{IV. and VI.}}$.—Certain Marks (III., IV. and VI. 6-inch ordinary B.L.) have been converted into Q.F. guns. The Mark under the line in each case is the mark of the original piece. The hood is removed and steel chamber and bore liners are inserted, the former adapted to suit the metallic case. The bore liner may be short, half, or through, according to the amount of wear of the



Ordnance, Q.F.:—

12-pr. 12-cwt. (Mark I.)



Ordnance, Q.F., 6-inch, B.—*Single-motion breech mechanism.*

gun. With a through liner, Mark III. system of rifling would be used.

The "single motion" breech mechanism is employed, as with the "B" guns.

4·7-inch Q.F. Gun, Marks I. and II., *of* 41 *cwt.*—Mark I. is of steel, and consists of an A tube and 2 A hoop (prolonged for the reception of the breech screw), secured by shoulders and by a ring screwed in at the breech; five hoops extend to the muzzle, and a breech ring is shrunk on for attachment of the oil buffers. Exterior longitudinal projections form guides for the gun in the cradle. Mark II. differs only slightly in construction.

Mark III. consists of an A tube, jacket, B hoop, and 1 B and 2 B tubes extending to the muzzle.

Mark IV. weighs 40 cwt., and is of steel and wire construction; layers of steel wire being shrunk round a portion of A tube and secured to steel rings. A jacket and B tube form a third layer, being screwed together by a C hoop, a breech bush receiving the breech screw.

Breech mechanism.—The mechanism is similar in all Marks, and is that described for 6-inch Q.F. I. to III. guns, but the tappet ring is only used with Mark IV. gun. The firing mechanism is also similar to the 6-inch, excepting that an insulated contact for electric firing is fitted to the end plate of the gun in place of the mounting, and for percussion firing a striker is substituted for the striker and needle used with the electric gear.

4-inch Q.F. Gun, Marks I., I.A., I.B., *of* 26 *cwt.*—These are of steel and wire construction; the wire extends about half way; and over it and the remainder of A tube is shrunk a jacket extending to the muzzle, the jacket being secured by shoulders and a breech bush, the latter also receiving the breech screw. A breech ring is screwed on, and a longitudinal rib on the upper surface of the gun forms a guide for the gun in the cradle. A chamber liner is provided except in Mark I.A., which has additional wire at that part; Mark I.B. has an A tube thicker over the chamber, and no liner.

Mark II. gun is of steel and wire construction, weighing 26 cwt., and differs from the above in having trunnions; it has also a shorter jacket and a B tube extending to the muzzle, the two being connected by a trunnion ring; in addition an elevating band is fitted to the jacket.

Breech mechanism.—In all Marks of 4-inch Q.F. the breech is closed by a parallel left-handed screw, having three longitudinal portions slotted away. A carrier supports the breech screw, which is worked by a cam lever. The firing mechanism is similar, except in minor details, to 4·7 and 6-inch guns.

Mark II. gun is sighted on both sides with ordinary sights; but in Mark I. gun the cradle is provided with a graduated elevating arc and reader.

12-*pr. of* 12 *cwt.*, Mark I.—This gun consists of an A tube with jacket which receives the breech screw; a B tube extends to the muzzle, a C hoop uniting the latter and the jacket. Guides for the cradle are provided.

12-*pr. of* 8 *cwt.*, Mark I.—This gun is of similar construction, but is 3 feet shorter.

The breech mechanism of both guns is "Single Motion." The electric and percussion firing mechanisms are similar in principle, and differ only in minor details from those already described.

Sights.—For both land and sea service, sights of ordinary pattern are used.

6-*pr. Q.F. Hotchkiss Gun*, Mark I.—This gun is of steel, and consists of an A tube and jacket which receives the breech mechanism; there is also a small hoop in front.

The tube and jacket are locked together by a screwed collar, which carries the foresight.

The breech mechanism comprises a breech block or wedge, crank and crank handle, for moving the wedge up and down, main spring, trigger, gear and extractor. The movement of the crank handle opens and closes the breech, the breech block or wedge sliding upon guides in the sides of the breech recess. At the first motion the breech is opened, the fired cartridge extracted, and the hammer cocked for the next round. A cartridge is inserted in the chamber, and the wedge being moved upwards at the same time forces the cartridge home, the gun being then fired by the trigger; and in Mark I.* guns an arrangement is made for re-cocking without opening the breech, in the event of a miss fire.

The weight of the piece (without pivot) is 7 cwt. 2 qrs. 9 lbs.; length, 97 inches; calibre, 2·244 inches; length of bore, 89·76 inches; system of rifling, polygroove (plain section); number of grooves, 24.

Mark II. is similar, but is provided with sights and fittings suitable for land service.

3-*pr. Hotchkiss Q.F. Gun*, Mark I.—The weight of this gun is 4 cwt. 2 qrs. 24 lbs.; length, 80 inches; calibre, 1·85 inches; length of bore, 74 inches; number of grooves, 20; in other respects it is similar to the 6-pr. Hotchkiss.

Mark II. is similar, but for land service it is mounted on a travelling carriage, and the shoulder-piece is not therefore required: there are other minor differences, and the gun is fired by a lanyard.

It is sighted with ordinary pattern sights on the right side.

6-*pr. Q.F. Nordenfelt Gun*, Mark I.—The gun is of steel, and

TABLE II.—Q.F. GUNS.

Guns.	Mark.	Service: Land, Naval, or Common.	Nominal Weight.	Calibre in Inches.	Total Length in Inches.	Muzzle Velocity. Fcot Secs.	Penetration of Steel at 1000 yards.	List of Changes. W. M.	Remarks.
3-pr. Nordenfelt	I.	L.	4 cwt.	1·85	91·5	1920	1·5 inch	6495	
„ Hotchkiss	I. & II.	N.L.	5 „	1·85	80·6	1873	1·5 „	5134, 6555	
6-pr. Nordenfelt	I., II. & III.	N.L.	6 „	2·244	104·4	1818	2 inches	5099, 5461, 6284	
„ Hotchkiss	I. & II.	N.L.	8 „	2·244	97·63	1818	2 „	5008, 6283	
12-pr.	I.	N.	8 „	3	87·6	1607(*b*)	2·8 „	7747	
„	I.	C.	12 „	3	123·6	2210(*b*)	4 „	7724	
4-inch .. (*c*)	I., IA., IB. & II.	N.	26 „	4	165·25	2456(*b*)	5·4 „	8244–45	(*c*) Wire construction.
4·7-inch	I. & II., III. IV.B.	C.	41 „	4·724	194·1	1786 2188	5·4 „ 7·7 „	6010–11 6571, 7119, 8094	
6-inch	I., II., III.B.	N.	7 tons	6	249·25	1882(*a*) 2000(*b*)	8 „ 9·4 „	6713, 7012 7055, 8261	(*a*) Powder. (*b*) Cordite.
6-inch Q.F. converted from B.L.	I. / IV. & VI. II. / III., IV. & VI. III. / IV. & VI.	N.	7 tons	6	249·25	1882(*a*) 2000(*b*)	8 „ 9·4 „	8269–70	B. When fitted with single motion breech mechanism.

[*To face p.* 28.

consists of an A tube over which is shrunk a jacket, prolonged at the rear for the breech mechanism; the jacket is secured longitudinally by interlocking, a small hoop being shrunk over it.

The parts of the breech mechanism are: the firing handle; action cam; breech block; wedge; and extractor.

The block is hinged in a recess at the breech, the wedge being attached to its rear face. To open the breech the lever is drawn back, this forces down the wedge, at the same time throwing it and the breech block back: to close the breech the lever is pushed forward. The gun can be fired by the action of closing the breech or by a lanyard as required. Hand wheels are used for elevating and traversing.

The weight of the gun (without pivot) is 5 cwt. 2 qrs. 22 lbs.; length, 104 inches; calibre, 2·244 inches; length of bore, 95 inches; the rifling is similar to the Hotchkiss gun.

Mark II. differs in having a thicker jacket and a B hoop. A shoulder-piece for elevating and traversing is also provided, and the gun is fired by a trigger; its weight is 6 cwt. 1 qr. 19 lbs.

3-*pr. Q.F. Nordenfelt Gun*, Mark II.—The gun is of steel, and consists of a jacket with B hoop screwed to it for longitudinal strength, shrunk over an A tube. The breech mechanism is similar to the 6-pr. gun; it has no shoulder-piece or loading shield, and is fired with a lanyard; it is mounted on a travelling carriage for land service.

Ammunition for Q.F. Guns. Cartridges, 12-pr. to 6 inch.

6-*inch Q.F. Cartridge*, Mark I.—The empty cartridge is of brass, the body and head being screwed together, and the mouth notched for turning over the lid: in the base there is a threaded hole to take an electric primer or an adapter, the latter being for use with vent-sealing tubes for percussion firing.

The charge in the case consists of 29¾ lbs. of E.X.E. powder, contained in two portions in shalloon bags; the mouth of the cartridge case being closed with a felt wad and lid.

Mark II. is very similar, but can be used with either a powder or cordite charge. The latter consists of 13 lbs. 14 oz. of cordite, size 30, with an igniter. A paper cylinder is used to fill up the space in the case, a mill-board and felt wad and lid being then inserted.

Mark III. empty cartridge is shorter, being only suitable for a cordite charge.

4·7-*inch Q.F. Cartridge*, Mark I., is obsolete; Mark II. is of solid drawn brass, and is filled with 12 lbs. S.P. powder; it has a lid, and hole for primer or adapter, similar to the 6-inch cartridge.

Mark III. cartridge is filled with 5 lbs. 7 oz. of cordite, size

20, with an igniter; and is provided with a paper cylinder, felt wad and lid. These cartridges are packed six in a box.

4-inch Q.F. Cartridge, Mark I.—The case is of solid drawn or built up brass, and is filled with 3 lbs. 9 oz. of cordite, size 15. It has an electric primer or adapter, igniter (1¼ oz.), wad and lid. The weight of the filled cartridge is 12 lbs. 8 oz., eight being packed in a box.

12-pr. of 12 cwt. Cartridge, Mark I., is of brass and is filled with 1 lb. 15 oz. of cordite, size 15, or 1 lb. 9½ oz. size 10, with an igniter of 8½ drams of powder; a paper cylinder, felt wad and lid are inserted when filled. The cartridge weighs 7 lbs. 10 to 12½ oz.; ten are packed in a box.

12-pr. of 8 cwt. Cartridge, Mark I., is similar, but the charge is 13½ oz. of cordite, size 10.

Igniter, Mark I.—The igniter used with cordite charges of Q.F. cartridges consists of a paper cylinder closed and pointed at one end, the other being open; it is filled with 1 oz. 4 drams of R.F.G.$_2$ powder, or 8 drams in the case of 12-pr. cartridges: the igniter is screwed on to the cap of the electric primer or to the end of Mark II. Adapter, which is threaded for the purpose.

Primer, Electric, Mark I.—The primer is of manganese bronze, and is screwed into the primer hole of Q.F. cartridge cases; for electric firing a steel needle in the axis of the breech screw makes electric contact with the primer on firing. Mark II. primer is stronger, and has a threaded end to take the igniter; its length is 2·35 inches.

Adapter, Mark I.—The adapter used with Q.F. cartridges is of steel, and is similar in form to a primer, but somewhat larger; it takes a vent-sealing percussion tube for firing by percussion. Mark II. Adapter is shorter, and has a threaded end on which the igniter is screwed.

Projectiles for Q.F. Guns.

The following are the projectiles used with Q.F. guns: With 12-pr. Q.F., shrapnel shell, of the pattern in use with 12-pr. B.L. guns, and in addition armour-piercing and common shell. With 4-inch Q.F. the projectiles, with the exception of an armour-piercing shell, are those in use with 4-inch B.L. guns. With 6-inch Q.F. the projectiles are those employed with 6-inch B.L. guns.

6-inch Q.F.—The projectiles are: Palliser shell, taking the large base percussion fuze No. 11; bursting charge of powder, 1 lb. 8 oz.; weight, filled and fuzed, 100 lbs.; cast steel pointed common shell, with a bursting charge of 9 lbs. 4 oz. of powder,

[*To face page* 30.

TABLE III.—R.M.L. ORDNANCE.

Guns.	Mark.	Service: Land, Naval, or Common.	Nominal Weight.	Length of Bore in Calibres.	Total Length in Inches.	Muzzle Velocity. Foot Seconds.	Penetration of Wrought Iron at 1000 yards.	Remarks.
7-pr. .. (*a*)	II.	N.	200 lbs.	10·7	38·125	914	..	(*a*) II. of bronze, III. and IV. of steel.
„	III.	L.	150 „	8·0	29·125	673	..	
„	IV.	C.	200 „	12·0	41	950	..	
2·5-inch (*b*)	I.	L.	400 „	26·6	70·45	1440	..	(*b*) Jointed gun.
9-pr. .. (*c*)	I.	N.	6 cwt.	17·67	61	1250	..	(*c*) Wrought iron & steel.
„ .. (*d*)	II., III. and IV.	C.	6 „	22·0	74·5	1390	..	(*d*) Steel.
„	I. and II.	C.	8 „	21·17	72	1390	..	
13-pr.	I.	L.	8 „	28·0	92	1595	..	
15-pr. .. (*e*)	I.	L.	422 lbs.	20·0	70·5	1040	..	(*e*) Jointed gun.
16-pr.	I.	L.	12 cwt.	19·0	78	1355	..	
25-pr.	I.	L.	18 „	22·0	98	1350	..	
40-pr.	I.	L.	34 „	18·0	100·5	1340	..	
„	II.	L.	35 „	22·0	120	1425	..	
64-pr.	I. and II.	L.	64 „	15·47	120	1125	..	
„	III.	C.	64 „	15·47	118	1390	..	
6·6-inch ..	I.	L.	70 „	14·78	118	1416	..	
7-inch	I.	N.	90 „	15·86	131	1325	7 inches	
„	III.	C.	6½ tons	15·86	133	1525	8 „	
„	IV.	L.	7 „	18	148	1561	8 „	
8-inch	I. and III.	C.	9 „	14·75	144	1390	8 „	
9-inch	I. to V.	C.	12 „	13·89	156	1440	10 „	
„ .. (*f*)	IV.A., B. & C.	L.	12 „	13·89	145·75	1194	..	(*f*) High-angle fire guns.
10-inch	I. and II.	C.	18 „	14·55	180	1379	12 inches	
„ .. (*g*)	III.	L.	12 „	12·5	145·75	..	..	(*g*) High-angle fire gun.
10·4-inch (*h*)	I.	L.	28 „	26	289	1810	17 inches	(*h*) Modern design.
11-inch	I. and II.	C.	25 „	13·18	180	1360	13 „	
12-inch	I.	C.	35 „	13·54	195	1340	14 „	
„	II.	C.	25 „	12·09	182	1292	12 „	
12·5-inch ..	I.	C.	38 „	15·84	230	1442	16 „	
„ ..	II.	C.	38 „	15·84	222·8	1575	17·7 „	
16-inch	I.	C.	80 „	18	321	1540	23 „	
17·72-inch ..	I.	L.	100 „	20·48	391·85	1548	23 „	
Howitzers:								
4-inch (*k*)	I.	L.	600 lbs.	13	57·45	835	..	(*k*) Jointed piece.
6·3-inch ..	I.	L.	18 cwt.	7·14	56	751	..	
6·6-inch (*i*)	I. and II.	L.	36 „	12	90·7	839	..	(*i*) Mark II. of steel.
8-inch ..	I.	L.	46 „	6	64	697	..	
„ (*i*)	I. and II.	L.	70 „	12	113	956	..	

taking No. 11 fuze. Forged steel common shell, filled with 13 lbs. 12 oz. of lyddite; this shell has a solid base and takes a nose fuze of G.S. gauge.

4·7-inch Q.F.—The projectiles for this gun are: Forged steel armour-piercing shell, Mark IV., taking the medium base percussion fuze No. 12; bursting charge, 1 lb. 12 oz. of powder; weight, filled and fuzed, 45 lbs. Cast steel pointed common shell, Mark IV., taking No. 12 fuze; bursting charge, 4 lbs. $3\frac{3}{4}$ oz. of powder. Forged steel common shell filled with 7 lbs. 5 oz. of lyddite, taking a nose fuze of G.S. gauge. Forged steel shrapnel shell, containing 225 mixed metal balls, 34 to a pound; bursting charge, 5 oz. of powder.

4-inch Q.F.—The projectiles used are: Forged steel armour-piercing shell, taking No. 12 fuze; bursting charge, $13\frac{1}{2}$ oz. of powder; weight, filled and fuzed, 25 lbs. Palliser shell taking No. 12 fuze; bursting charge, $3\frac{1}{2}$ oz. of powder. Cast steel pointed common shell, taking No. 12 fuze; bursting charge, 2 lbs. of powder.

12-pr. Q.F. of 12 cwt.—The projectiles used are: Forged steel armour-piercing shell, Marks I. and II.; bursting charge, $6\frac{1}{2}$ oz.; Mark I. takes the Hotchkiss base percussion fuze; Mark II. No. 12 base fuze.

12 pr. Q.F. of 8 and 12 cwt.—The projectiles used are: Cast steel pointed common shell; bursting charge, 1 lb. 3 oz.; Mark I. takes the Hotchkiss base fuze; Mark II. takes No. 12 base fuze. Iron pointed common shell, with No. 12 base fuze; bursting charge, 13 oz. of powder. Forged steel shrapnel shell, containing 150 balls, 35 to a pound, contained in a perforated tin cylinder; bursting charge, $1\frac{1}{2}$ oz. R.F.G_2 powder.

Cartridges for 3-pr. and 6-pr. Q.F. Guns.

The cartridge cases for these guns are of solid drawn brass; in the centre of the base being a cap, cap chamber and anvil.

The metallic case of the 6-pr. contains 1 lb. $15\frac{1}{2}$ oz. of Q.F. powder, or $7\frac{3}{4}$ oz. of cordite, size $\frac{5}{11}$: that of the 3-pr. 1 lb. 8 oz. of powder or $6\frac{3}{8}$ oz. of cordite, size $\frac{5}{11}$.

When the case is filled with powder, a felt wad is placed over the charge; when cordite is used a white paper lining is inserted in the case, which is not then lacquered inside; and with cordite an igniter of 4 drams of R.F.G^2 powder is placed next to the cap, also a paper cylinder and felt and mill-board wads are used to fill up the vacant space in the case.

The projectiles used are steel shell and iron common shell; both

natures being filled and fuzed at their bases. The practice projectile is an iron plugged shell with a blunted point.

The shells are attached to the metallic cases by indenting the latter into the cannelure on the driving bands.

The 6-pr. powder-filled cartridge case with projectile weighs 10 lbs. 3 oz.; and when cordite is used, 9 lbs. The 3-pr. with powder weighs 6 lbs. 15 oz., and with cordite 6 lbs.

Fuzes.—Base fuzes are used of Hotchkiss or Nordenfelt pattern.

The Hotchkiss base fuze has a metal body containing a percussion pellet and cap. In Marks II. and III. fuzes a detonator is used as with the R.L. fuze No. 7. The pellet consists of a brass casing filled with lead, having embedded in it a roughened brass needle; on discharge, the pellet sets back along the needle, exposing its point; on impact, the pellet and needle are driven forward against the cap. In Mark III. fuzes there is a spiral brass spring between the point of the needle and cap to prevent prematures owing to rebound.

The Nordenfelt base fuze consists of a metal body; percussion pellet with detonating cap; split safety collar; and a needle screwed into the top of the body.

The lower portion of the safety collar is split down on one side and fits over the pellet; its upper portion being smaller in diameter. On discharge the collar sets back over the pellet, thus exposing the detonating cap; and on impact the pellet with cap is free to fly forward against the needle.

Mountings for Q.F. Guns.

The mountings adopted up to the present in the land service for Q.F. guns are as follows.

Carriage, Garrison, Q.F. 4·7-inch central pivot, Mark I.—This mounting consists of a cradle, lower carriage, and pedestal with pivot; and also of a shoulder-piece, elevating and traversing gear, pivot plate, live roller ring, and outer and inner shields. The gun recoils about 8 inches in the cradle, which is fitted with an hydraulic buffer, the piston rod of which is attached to the breech ring of the gun; a running-out spring is compressed during recoil, and returns the gun to its firing position. The cradle is pivoted by its trunnions to the lower carriage, and the latter is bolted to the inner shield and riveted to a base plate, on the under side of which is a roller path. The mounting on its base plate revolves on a live roller ring running in the roller path, which is bolted to the pedestal; the latter has a central pivot and is fixed to the emplacement.

Elevating and traversing gear are attached on the left side of

the carriage, and 20° elevation or 10° depression can be given to the gun: the shoulder-piece on the left side is used when rapid training is required: both the gun and mounting are protected by a top shield and an inner shield, the latter being automatically raised by counterweights as the gun is elevated, and so completely protecting the port.

Carriage, Garrison, Q.F., 12-pr., Mark I.—This mounting consists of a cradle, pivot, pedestal and holding-down plate, also a shoulder-piece, elevating gear and shield. The gun recoils about 12 inches in a cradle, in the lower portion of which are a recoil buffer and running-up spring. Trunnions are provided for the cradle, which pivots in trunnion bearings on the fork-shaped end of a pivot; the lower end of the latter revolves in the pedestal, which is bolted to the holding plate fixed in the emplacement.

A shoulder-piece for traversing, and a pistol grip, are attached to the left side of the pivot. The mounting permits of 20° elevation and 15° depression to the gun.

Carriage, Q.F., Recoil, 6-pr., Mark I.—This mounting is used in the land service for 6-pr. Hotchkiss Mark I., or Nordenfelt Mark III. guns.

The carriage consists of a sliding cross-head, cradle, pivot, shoulder-piece and trigger guard. The gun is secured to the cross-head which slides in the cradle, the latter being provided with hydraulic buffers to check the recoil. The cradle is supported by trunnions, pivoting in bearings on the fork-shaped steel pivot, the lower end of which fits into a socket bolted to a saddle that is fixed in the sill of an embrasure, or, when mounted in other positions, the pivot fits into the socket of a fixed cone of steel plate. The mounting permits of 20° elevation and depression being given.

Carriage, Q.F., 3-pr., Travelling.—This carriage is for use with Hotchkiss Mark II. and Nordenfelt Mark I. guns. The trail is formed of two side brackets connected by the trail eye, transoms and a bracket, the latter having guides in which slides the cradle. The cradle is provided with buffers and a spring for running the gun up to its firing position. The gun is carried on a fork-shaped pivot having trunnion bearings, the pivot fitting in a socket in the cradle. Elevating and traversing hand wheels are provided, and seats for the two numbers serving the gun: wheel brakes, to assist in checking recoil and for travelling, are attached, and a steel bullet-proof shield is fixed in front of the carriage.

The limber consists of a steel frame attached to an axle-tree by springs; the limber box, containing 10 compartments, each holding 9 rounds, being bolted to the frame. The lid of the box opens to the rear, and, resting on a curved stay, forms a shelf for the ammunition numbers.

CHAPTER IV.

RIFLED MUZZLE-LOADING ORDNANCE.

Construction and Manufacture.

The general features of R.M.L. ordnance have been referred to previously, the details of their construction and fittings will now be considered.

Although these pieces have been obsolete for many years as regards manufacture, numbers still remain mounted in our coast defences at home and abroad, and a knowledge of their construction and use is as necessary as heretofore.

Construction.

All natures are built up of wrought-iron coils shrunk over a steel barrel or A tube, with a very few exceptions.

A Tube.—An inner barrel or A tube is formed out of a solid ingot of cast steel, which is forged and drawn out to the required length under the hammer. Specimens having been cut off the breech for testing purposes, the tube was rough bored, and oil hardened or tempered, a water test being applied for the detection of flaws.

Manufacture of a Coil.—A coil was made of flat bars rolled out from blooms of wrought iron. Several such bars were piled together, the outer ones being of puddled iron, to give a smooth surface, and the inner of scrap, to furnish fibre; the number of the bars depending on the size of coil to be made.

The pile of flat bars at welding heat were then rolled in the mill, into a single bar of the required length, usually about 24 feet, and of trapezoidal section. By this rolling process a fibre running lengthways was also imparted to the bar. The bar being again heated, was then coiled round a revolving mandril placed in front of the furnace; the coil thus formed being thoroughly forged and welded together under a steam hammer, and afterwards turned and bored to finished dimensions. The fibre now running round the coil adds considerably to its strength.

PILE FIG. 1.

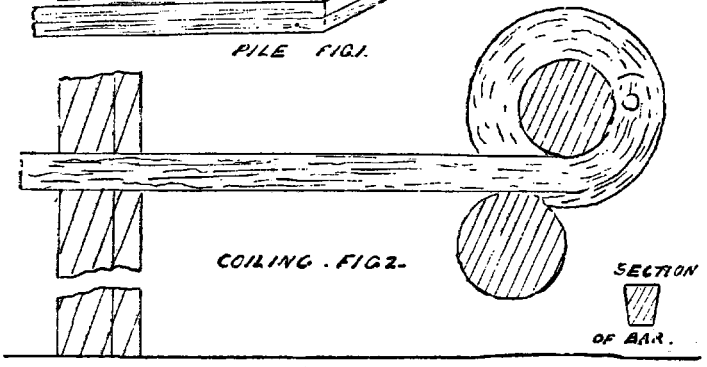
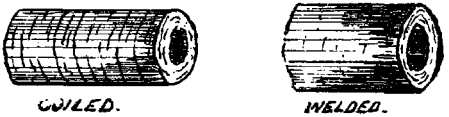


FIG 3.



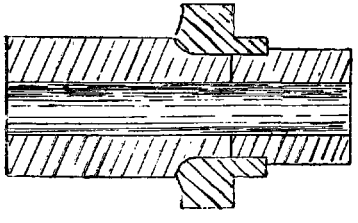
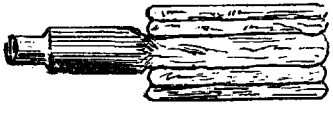
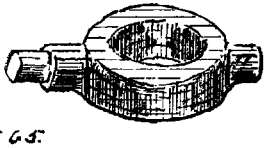


FIG 4.
JACKET
READY FOR
WELDING.

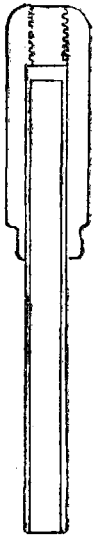


TRUNNION RING.



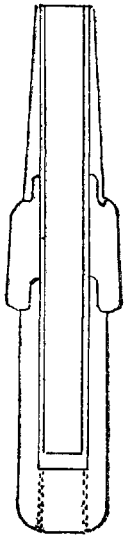
F. G 5.

FIG. 1.



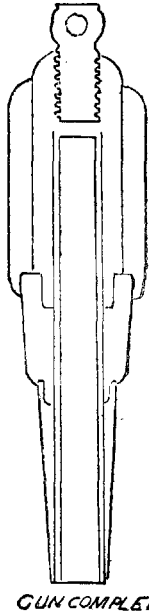
A TUBE & COILED BREECH PIECE.

FIG 2



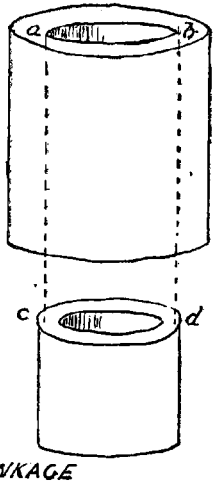
A & B LAYERS

FIG. 3



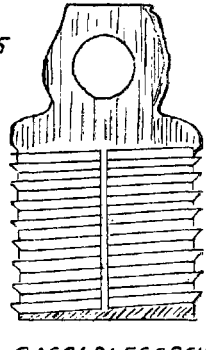
GUN COMPLETE.

FIG. 4.



SHRINKAGE

FIG 5



CASCABLE SCREW.

Manufacture of a B Tube.—A B tube is composed of two slightly tapered coils that were shrunk together lengthways, a shoulder being formed in the one, and a corresponding recess in the other; the joint was afterwards completely welded under the hammer.

Manufacture of a Jacket.—A jacket is composed of a breech coil, a forged trunnion ring and a short muzzle coil. The trunnion ring, brought to a red heat, was dropped over the breech coil, and the muzzle coil then inserted: the ring on cooling gripped the parts together, and the mass was further welded.

Trunnion Ring.—This is a solid forging, and was made of slabs of iron welded together on the flattened end of a porter bar. A ring was formed by driving tapered mandrils through its centre, and the trunnions having been roughly brought into shape, the trunnion ring was cut off the bar and bored out.

Cascable Screw.—The cascable is a solid forging, with the fibre running lengthways, a screw thread being cut on its outer surface; it is permanently screwed through the breech of the gun, and made to abut against and so support the end of the A tube. The front thread on the screw is cut away, and a channel made at right angles to the remaining threads so as to provide a gas escape, by which means any unsoundness in the barrel is at once indicated.

Building up an R.M.L. Gun.—An R.M.L. gun, for example a 10-inch, was built up as follows: the A tube was placed in the shrinking pit, with its muzzle end down; a coiled breech-piece, heated on a wood fire to expand it, was then dropped over the tube, cold water being injected at the same time into the latter to lower its temperature during the shrinking-on process. On the normal temperature of both being regained, the coil remained in a condition of slight tension, whilst the tube was slightly compressed; the amount of shrinkage being equal to the compression plus the extension.

The A tube with breech-piece was then inverted, and 1 B coil, and afterwards the B tube were shrunk over it from the muzzle end.

The partly built-up gun, consisting of the A tube and B, or first layer, was then rifled, and the cascable screwed in, care being taken to ensure the latter bearing well against the end of the A tube; and, in order to distribute the longitudinal strain over the breech-piece, a shoulder was turned on the outer surface of the tube, thus relieving the pressure on the threads of the cascable screw.

The building up was then completed by shrinking on the C coil or jacket, this operation having been delayed for convenience

until the different machine operations had been carried out. In addition to being rifled, the bore was made truly cylindrical by "broaching"; and by "lapping," with lead and emery powder and oil, it was brought to plan size throughout its length and all burrs removed.

Details of Construction of Natures of R.M.L. Ordnance.

9, 13, 16 *and* 25-*pr. Guns.*—These guns are each composed of a jacket and steel tube; the 13-pr. Mark II. gun has a jacket also of steel.

40-*pr. R.M.L.*—This gun is exceptional, having a jacket, 1 B coil and B tube.

6·6-*inch.*—This gun is composed of a breech-piece and B tube, a jacket and C coil forming a third layer of metal.

9-*inch High-Angle Fire Gun.*—The 9-inch Mark VI. gun is the 9-inch Marks I. to V., altered to suit the mountings for high-angle fire. The alteration consists in removing the cascable, and the gun is also re-tubed and rifled on the polygroove system. In Mark VI.A guns the trunnions are adjusted to suit guides in the high-angle mounting. Mark VI.B and VI.C are slightly different, in having brackets to suit other patterns of H.A. mountings. The mountings to suit these marks are described later.

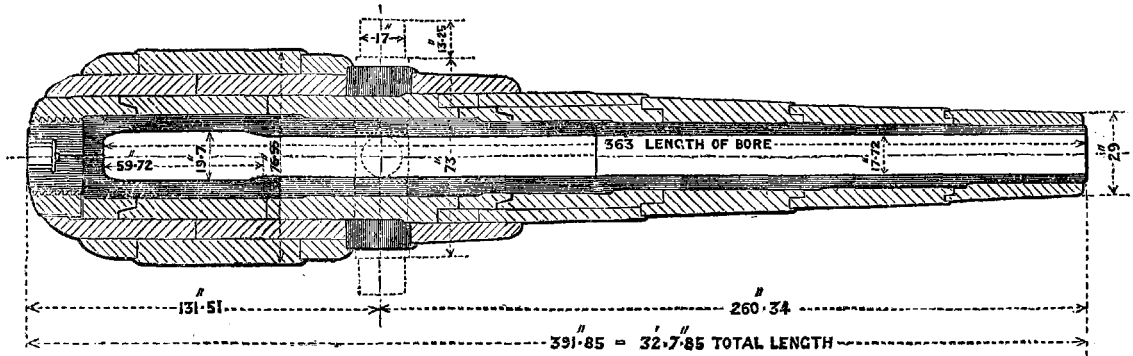
10-*inch Mark III. High-Angle Fire Gun.*—Certain 9-inch guns, Marks I. to III., have also been converted to 10-inch Mark III., for use on high-angle mountings (7339).

16-*inch, of* 80 *tons.*—This gun has a 2 B coil shrunk on between 1 B coil and the B tube on account of its greater length.

17·72-*inch, of* 100 *tons.*—This gun is of Elswick design, and consists of an inner barrel of tough steel in two portions, the joint being covered by a steel ring in halves; a series of sixteen wrought-iron coils and a trunnion ring are shrunk on successively, and a forged wrought-iron block is screwed in at the breech to support the A tube, there being no cascable proper.

Jointed Pieces of Ordnance.—The 2·5-inch gun of 400 lbs., the 15-pr. gun of 422 lbs. and the 4-inch howitzer of 400 lbs., are made of steel, and consist each of a breech and muzzle portion; the two parts being separate, and joined when the piece is required for use. In the 2·5-inch the breech portion is made from a solid block of steel, and has a screw thread on its front end, to receive the junction nut or trunnion ring; the muzzle portion comprises a steel chase and trunnion ring, the chase having a muzzle swell for strength.

Scale, $\frac{1}{70}$.



16-INCH. 80 TONS. MARK I.

Scale, $\frac{1}{70}$.

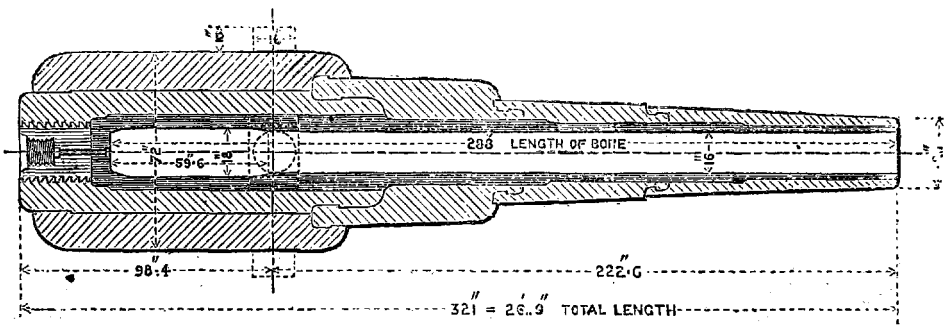
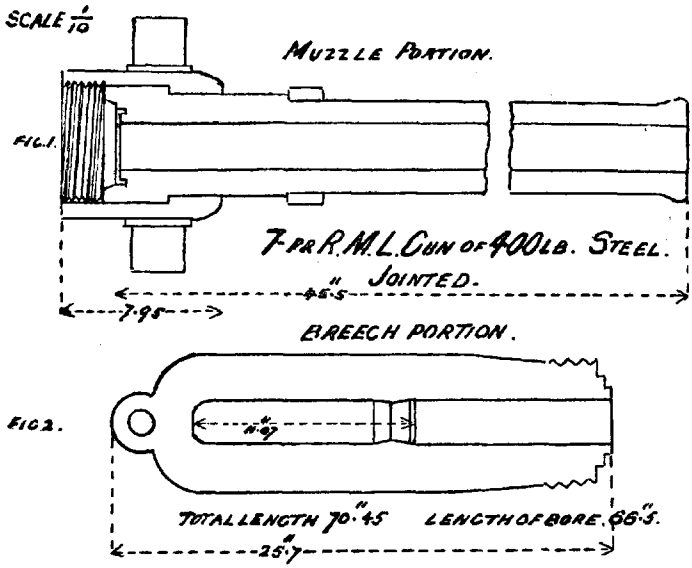


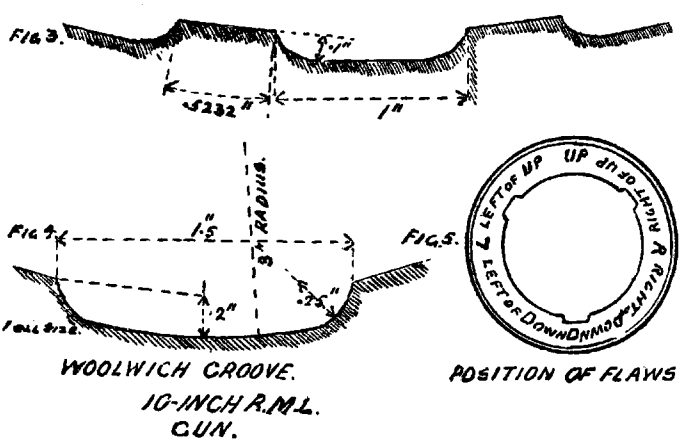
PLATE X.

[To face p. 36.

PLATE XI.



POLYGROOVE RIFLING, PLAIN SECTION, 16-INCH R.M.L.
FULL SIZE.



WOOLWICH GROOVE.

16-INCH R.M.L. GUN.

POSITION OF FLAWS

The two parts are brought into juxtaposition with a shoulder and recess joint, a gas ring sealing the joint: a projection in the muzzle, and corresponding recess in the breech portion, ensure the correct position of the parts, and their union is effected by screwing up the trunnion ring or nut.

Systems of Rifling of R.M.L. Ordnance.

Systems.—In R.M.L. ordnance, rotation of the projectile is effected by means of studs attached to the latter, or, secondly, by a copper gas check, which on discharge becomes firmly attached to the base, and is itself pressed against the walls of the bore and into the grooves; when necessary, projections corresponding to the grooves being provided.

The disadvantages of the studs and grooves system as regards the gun are that the grooves, being necessarily few in number, must be wide and deep, and therefore weaken the bore: also there is "windage" or space round and over the top of the projectile especially, and the rush of powder gas through this space caused loss of gas energy, and damaged the bore by scoring and erosion. The introduction of gas checks overcame the latter defects; although at first only used for that object, an improved form, and termed an automatic gas check, enabled rotation also to be given by its means; hence the use of studs was discontinued.

Guns constructed subsequently to this change were polygrooved with a number of shallow grooves, there no longer being any reason for a small number of deep ones.

With a few exceptions, then, the gas check has been adopted as a means of rotation for R.M.L. ordnance, whether rifled on the old system or polygrooved.

Twist of Grooves of Rifling.—The velocity of rotation of a projectile depends on the amount of twist of the grooves, and also on its forward velocity. The twist is measured by the length in calibres in which the groove or projectile makes a complete turn; so that in the case of the 10-inch R.M.L. gun, which has a twist of 1 in 40 at the muzzle and a muzzle velocity of 1364 f.s., the number of revolutions per second made by the projectiles is found by the expression $\frac{1364 \times 12}{40 \times 10} = 40\frac{3}{4}$ revolutions per second.

The necessity of an increased rate of twist with low velocity guns, in order to give the requisite number of revolutions, and therefore steadiness in the flight of the projectile, is evident from the above. The twist may be "uniform" or "increasing," or merge from one to the other. A groove of the former would be

represented by a straight line if laid out on a plane surface, and by a curve in the latter case.

The object of an increasing twist is to allow the shot to start easily, its velocity of rotation gradually increasing as it passes through the bore.

The grooves of R.M.L. guns have a uniform twist in 7-inch and lower natures, and an increasing spiral in higher natures.

Section of Grooves of Rifling.—In 25-pr. guns and upwards, except 64-pr. and polygrooved guns, the Woolwich groove is used. The bottom of the groove is struck with a radius of 3 inches, its width being 1·5 inch and depth 0·2 inch for 7-inch and upwards.

The "French modified" for 9 and 16-pr. guns, and the "French" for 7-pr. guns are employed, these being grooves of different section; for 64-pr. guns the "plain groove" is used.

In the case of 10-inch guns and higher natures, the loading side of the groove is cut away at the muzzle, and the bore there is enlarged or bell-mouthed for facility of loading.

The grooves commence in front of the seat of the charge or powder chamber in the case of chambered pieces.

Polygrooved Rifling.—The "polygroove plain section" groove is used with the following R.M.L. ordnance, viz. 2·5-inch of 400 lbs.; 13-pr.; 15-pr. of 422 lbs.; 6·6-inch; 80-pr. of 80 cwt.; 9-inch of 12 tons, Mark VI.; 10-inch of 12 tons, Mark III.; 10·4-inch of 28 tons; 16-inch of 80 tons; and 17·72-inch of 100 tons.

Chambering of R.M.L. Ordnance.

The advantages of enlarging the space at the end of the bore to contain the charge has been already dealt with in the chapter on B.L. guns (p. 18). This principle of "air-spacing" the charge is more difficult of application with an M.L. than a B.L. gun.

The following pieces are, however, chambered, viz. 2·5-inch of 400 lbs., 13-pr.; 15-pr. of 422 lbs.; 6·6-inch; 9 and 10-inch H.A. guns; 10·4-inch; 12·5-inch Mark II.; 16-inch of 80 tons; 17·72-inch of 100 tons.

Vents of R.M.L. Ordnance.

Copper Vents.—The channel for communicating the flash of the tube to the charge is termed the vent or vent channel. As the rush of gas would soon wear away the channel if made in the

metal of the gun, a vent bush of hardened copper is screwed in, which can be at any time renewed. The channel through the bush has a diameter of 2–9ths of an inch, a tube being 2–10ths.

There are two natures of copper vent bushes, a "through" and "cone" vent; the former has a screw thread on its whole length, the latter a smooth coned end about $1\frac{1}{4}$ inch in length.

A "cone" vent is used where possible, a "through" vent being inserted when it is necessary to bore out the coned part in the gun owing to wear.

Radial or Forward Vents.—All R.M.L. ordnance (excepting those mentioned as having axial vents) have vents in a forward position. In 64-pr. guns and above, the vent is made to strike the bore at a distance of 4–10ths of the length of the charge from the base. This position was at the time found to give the best results for the ignition of the charge as regards pressures. In 10-inch and upwards, on account of the size of the breech, the vent is inclined at an angle of 45°, being at the side. In 40-pr. guns and under, and in howitzers, the vent strikes the bore close to the end on account of reduced charges being used with these pieces. The 13-pr. vent is 7 inches from the end.

Axial Vents.—The following R.M.L. pieces have axial vents, viz. 10·4-inch, 12·5-inch Mark II., 16-inch and 17·72-inch. The vent, which is removable, consists of a steel bolt containing the vent channel. The front end of the vent is mushroom-shaped, its rear being fitted with a cross-handled head prepared to receive either an electric or frictional vent-sealing tube. A copper washer placed between the mushroom head and end of the bore, makes a gas-tight joint; but the vent should be frequently removed for examination.

A safety shutter is provided to guard against accidents from defective tubes or from the head of the vent not being properly screwed up.

Sights of R.M.L. Ordnance.

Sights of Heavy Ordnance.—64-pr. R.M.L. guns and upwards were formerly all provided with three rows of sights, viz. side and central rows. The central row is now only retained for guns mounted behind shields, which may foul the side rows.

Tangent Sights.—The tangent or side sights are inclined at an angle to the left, to counteract "drift." On the front face of these sight bars are engraved a scale of degrees, the length of the degree corresponding to the radial distance between the fore and hind sight in each case. The rear faces of the bars of $7\frac{1}{2}$-ton gun sights and above, are fitted with removable "range strips" of

aluminium, graduated in yards for a full charge, and having the corresponding muzzle velocity marked.

In the case of 7-inch R.M.L. and above, "sights Tangent A" are used for guns mounted on sea fronts, and "sights Tangent B" for those on land fronts. The Tangent A sight consists of a rectangular steel bar with a gun-metal cross-head on which is engraved a deflection scale for 2° right and left. A deflection leaf of steel slides in the cross-head, being clamped in the required position by a screw in front. The leaf is provided with a vertical sighting blade of a height corresponding to 1000 yards, so that line can be readily obtained by the gun layer, standing on the sighting step in rear of the slide, elevation being then given by hydroclinometer, index plate, or other means. In new manufacture Tangent "A" sights for 9-inch guns and upwards for land service are made "left" and "right," and are so stamped: the vertical sighting blade of the left sight is turned inwards when in position in the gun, to correspond with the sighting blade of the left fore sight (8837). There is also a notch at the bottom of the blade 0·06 inch deep, for use when necessary.

Tangent B sights have deflection leaves without sighting blades.

Centre Hind Sights.—A centre hind sight consists of an hexagonal gun-metal bar in 7 to 12-inch R.M.L. guns; the bar having a cross-head and deflection leaf with a vertical sighting blade. The cross-head has a deflection scale up to $1\frac{1}{2}$° R and L. The front face of the bar has a degree scale, and the rear face a yards scale for full charge; these sights would only be used with guns on sea fronts behind shields. The centre sights of 12-inch and 12·5-inch guns are similar to the side sights of these pieces.

Fore Sights.—Fore sights of the drop pattern are used with all R.M.L. guns: the drop sight consists of a pillar and collar of gun-metal, and a hog-backed leaf or steel acorn point: it is dropped into a socket of gun-metal in the gun, and secured by a double bayonet joint. To remove the sight the collar is raised and the pillar then turned through a quarter of a circle. In new manufacture fore sights of 9-inch and upwards are provided with sighting blades to facilitate laying for line: the sights are left and right, and are so stamped: the vertical sighting blades are turned inwards when in position in the gun. (8837.)

Sights, Reflecting Hind, 12·5-inch.—These sights are used with 12·5-inch guns mounted in small ports. The fore and hind sight are placed 30 inches apart on the chase, the hind sight being provided with a movable mirror. The gun layer standing in front of the trunnions, facing the breech, brings the reflected object, fore sight and notch into line in the mirror.

Sights of 16-*inch.*—16-inch guns are not provided with sights, turret sights being used. Chase sights, as with 12·5-inch, are provided for exceptional use.

Sights of 17·72-*inch.*—17·72-inch guns have a row of reflecting sights on either side.

Clamps for Sights.—The clamps are of gun-metal and removable, being used to clamp side sights at any required elevation; a sight can be adjusted and clamped out of the gun.

Sights for Siege Ordnance.

French's Sights.—All siege pieces are fitted with "sights, cross-bar," known as French's sights; the sights being set vertically in the case of the howitzers.

Hind Sights.—The sights can be used either for "forward laying," with the object visible, or when an auxiliary mark in front is employed, or for "reverse laying," in which case an auxiliary mark in rear of the work is used for laying, the line of fire having been obtained. The sight bar has a bronze head with clamping screw, and a steel horizontal cross-bar; the cross-bar can slide within the head 1° to the right and 3° to left for deflection, and is provided with a sliding reversible leaf, with a notch for forward laying; whilst for use when reverse laying, there are a point and also cross wires for laying on an auxiliary mark when laying for elevation as well as line. The cross-bar is graduated to 8° right or left according to the side of the howitzer on which it fits; with siege guns this sight is only used on the right side.

Trunnion Sight.—This consists of a steel stem, having a solid forged horizontal cross-bar, graduated from 0° to 8° to correspond with the tangent sight. The cross-bar is fitted with a reversible sliding leaf, having a point for forward laying, and a notch and eye-hole for reverse laying.

Laying by French's or Cross-Bar Sights.—The sights can be used in the ordinary manner when the object is visible, except that both sliding leaves must be clamped at corresponding divisions of the cross-bars, to obtain a line parallel to the axis of the piece; deflection being given on the portion of the bar graduated for that purpose.

For laying on an auxiliary mark to the front or rear, the line of fire is first obtained, and the piece elevated by clinometer: for succeeding rounds it is laid on the selected auxiliary mark, the leaves of the cross-bars having been clamped in any position to suit. The piece can be laid for elevation and line if necessary by the auxiliary mark, in which case the bars are clamped at the

required heights and the window sights used; a clinometer, however, would be generally employed, and the laying point used for obtaining the line only.

Sights of 6·6-*inch.*—This gun, when mounted on a siege hydro-pneumatic carriage, is provided with one set of reflecting and one of ordinary sights.

Sights for Field and Light Pieces.

2·5-inch, 16-pr., 25-pr. and 40-pr. R.M.L. guns have two rows of side sights; 7-pr., 9-pr. and 13-pr. guns have one row of central sights.

The 13-pr. sights have an eye-hole in addition to a notch on the hind sight, and cross wires below a roughened acorn apex on the fore sight. Fore sights for all field pieces are screwed into their sockets.

Instruments for Laying Ordnance.

In addition to sights, clinometers, large or field, are issued for all R.M.L. ordnance for use when required on the clinometer plane, cut in all cases on the upper surface of the breech.

Hydro-clinometers and Index Plates and Readers are used with guns mounted on sea fronts; these instruments have been described previously (page 21).

Miscellaneous Subjects Connected with R.M.L. Ordnance.

Markings on Ordnance.—The broad arrow, Royal cypher, and weight are marked in front of the vent of R.M.L. ordnance, also parallel lines in the vent field denoting the end of the bore and of the rifling; and lines on the upper surface of a gun show the centre of gravity and half-weight mark. The "line of metal" is marked on the breech in the same vertical plane as the axis of the piece; there are also vertical and horizontal lines on the right trunnion and on the face of the muzzle.

On the left trunnion are inscribed the register number of the gun, a numeral signifying its mark, the year of its proof, also the initials of the factory where it was made.

Planes for Clinometers.—These are cut upon the upper surface of the breech of all R.M.L. ordnance.

Lanyard Guides.—These guides are screwed in near the vent of all R.M.L. ordnance except field guns; they provide a lead for the firing lanyard, and prevent the liability of the tube being jerked out, and so causing missfires.

Elevating Plates.—Metal elevating plates are screwed on both

sides of the breech for the attachment of the elevating gear, but in field guns the elevating screw is connected by a bolt passing through the cascable.

Trunnion Studs.—Studs are screwed into the trunnions of 38-ton guns for facilities in slinging a piece by the box beam or other apparatus; they are also used with other natures for specific purposes.

Muzzle Derrick.—A derrick is secured to the muzzle of 9-inch guns and upwards when mounted in open batteries; it is used with the hoisting tackle of the projectile in loading: the derrick is hinged to a band screwed over the chase, and a bridge piece allows it to project over the muzzle in the required position.

In casemated works the hoisting tackle is hooked on to a port bar.

Preserving Screws.—These are issued for all guns for screw holes, for use when fittings are removed from a gun.

Preponderance.—This term is used for the excess of weight of the breech portion of a gun in rear of the trunnions; excess under 3 cwt. is considered nil with heavy guns; the weight and preponderance of a gun are taken before it is issued from a factory.

Proof of Ordnance.—A gun before acceptance into the service is proved by firing one round with a full charge and two with a proof charge, i.e. $1\frac{1}{4}$ of the full charge, proof projectiles being used; after proof a water test is applied and gutta-percha impressions of the bore taken; it is then "lapped" to remove burrs, &c.

Examination of Ordnance.—A memorandum of examination or register sheet is issued with and accompanies every rifled gun; in this are recorded the material of the bore, a description of the construction of the gun with a sectional diagram: any defects existing are noted, also the number of rounds it has fired, and the result of all examinations.

The regulations direct that 12-inch 35-ton guns and upwards are to be examined after each series of 32 rounds; 9 to 12 inches after 50; 64-pr. to 9-inch after 100; below 64-pr. after 150 rounds. Before impressions are taken the bore is thoroughly cleansed by potash or by firing a scaling or small charge of powder.

Gutta percha impressions are then taken of the chamber and bore or any portion of it, and any new defects, or old ones that have increased, are noted: the position of a flaw is measured from the muzzle in inches, and is noted as "up," "right of up," &c., or "down," when facing the bore. Defects are rare in steel tubes, but longitudinal cracks occur occasionally which are serious; bad scoring and guttering, due to the heated gases of the charge, may affect the velocity and accuracy of a gun without being a source of weakness.

The vent channel of a copper radial vent may be enlarged, and fissures or hair lines may be found extending into the steel tube from the edge of the vent bush : a gun would be provisionally condemned if such lines are 1 inch long, or 0·5 inch if extending to the front or rear.

Cracks in steel present a zig-zag appearance under a magnifying glass, and can therefore be distinguished from tool marks or scratches, which show as continuous lines.

With regard to the exterior of a gun, outer coils occasionally shift; and defective welds may be seen, but, if near the muzzle, are unimportant.

Nomenclature of R.M.L. Ordnance.—R.M.L. guns of 6·6-inch calibre and upwards are designated by their calibre and weight; below 6·6-inch by the weight of the projectile fired and that of the piece ; howitzers by their calibre and weight. When below 5 tons weights are tabulated in cwts. ; in addition, the mark a piece bears is always shown ; a 9-inch gun, for example, would be fully designated thus : Ordnance, R.M.L., 9-inch (Mark VI.) *steel and wrought iron, 12-ton polygrooved.*

Use and Employment of R.M.L. and B.L. Ordnance.

The following are the purposes of which R.M.L. pieces are used in artillery service.

Mountain Service.—2·5-inch of 400 lbs., 7-pr. of 150 and 200 lbs., are used in the service of mountain artillery ; a battery of six pieces being a unit.

Field Artillery Service.—9, 13 and 16-pr. R.M.L. guns are employed with auxiliary or reserve field batteries; a battery of six pieces forming a unit. Service batteries of field artillery being armed with B.L. guns. With batteries of position 16, 25 or 40-pr. R.M.L. guns can be used.

Siege Artillery.—25 and 40-pr. R.M.L. guns, 6·3-inch, 6·6-inch and 8-inch R.M.L. howitzers constitute the armament of an R.M.L. siege train which would be formed into divisions, each containing 14 or 16 pieces. Heavy medium or light divisions would be employed according to the class of fortress to be attacked, the means of transport available, and the nature of the country to be traversed.

Medium Guns.—For land fronts of fortresses, and as an auxiliary armament for sea fronts, the following R.M.L. pieces are employed : 64-pr. of 64 cwt., 7-inch of 6½ tons, and also converted guns, viz. 64-pr. of 58 and 71 cwt., and 80-pr. of 5 tons, and in certain cases 6·6-inch or 8-inch R.M.L. howitzers.

Heavy Ordnance.—These pieces are usually mounted on the sea

fronts of fortresses for use in the primary attack of vessels; they include the following R.M.L. guns: 6·6-inch of 70 cwt., 7-inch of 6½ and 7 tons, 8-inch of 9 tons, 9-inch of 12 tons, 10-inch of 18 tons, 10·4-inch of 26 tons, 11-inch of 25 tons, 12-inch of 25 and 35 tons, 12·5-inch of 38 tons, 16-inch of 80 tons, 17·72-inch of 100 tons. For long range and high-angle fire in the attack of ships' decks, howitzers or 9-inch (Mark VI.) and 10-inch of 12 tons (Mark III.), guns would be employed, the guns being provided with high-angle mountings.

B.L. ordnance are, however, gradually replacing the old type of muzzle-loading pieces for use in the different classes to which ordnance is apportioned.

For Horse and Field Artillery.—12-pr. of 6 and 7 cwt., and 15-pr. of 7 cwt., B.L. guns form the armament of service batteries of horse and field artillery.

Siege Ordnance.—4 and 5-inch B.L. guns, and 4, 5, 5·4, 6, and 8-inch B.L. howitzers, are being substituted for R.M.L. pieces.

Medium Pieces.—For use as an auxiliary armament on sea fronts, and also for guns on land fronts, 12-pr. 4·7-inch and 6-inch quick firing B.L. guns are mounted in many positions.

Heavy Ordnance.—The modern guns of this class include the 6-inch, 8-inch, 9·2-inch, 10-inch, 12-inch, 13·5-inch and 16·25-inch B.L. guns, the latter being, however, for sea service only.

Movable or Light Armament of Fortresses.—For this purpose light R.M.L. and B.L. guns and howitzers, quick-firing guns up to 12-pr., and machine guns on travelling field or parapet carriages are employed.

Many years, however, will probably elapse before old types of ordnance, whether breech or muzzle-loading, will entirely disappear from the armament of our own or foreign fortresses, or from the navies of some, at any rate, of the foreign powers.

CHAPTER V.

R.M.L. CONVERTED GUNS; R.B.L. GUNS; AND SMOOTH-BORE ORDNANCE.

R.M.L. Converted Guns.

Natures.—The following smooth-bore pieces were at one time converted in large numbers into rifled guns by the Palliser system, viz. :—

32-pr. S.B. gun of 58 cwt. into 64-pr. R.M.L. gun of 58 cwt.

8-inch S.B. shell gun of 65 cwt. into 64-pr. R.M.L. gun of 71 cwt.

68-pr. S.B. gun of 95 cwt. into 80-pr. R.M.L. gun of 5 tons.

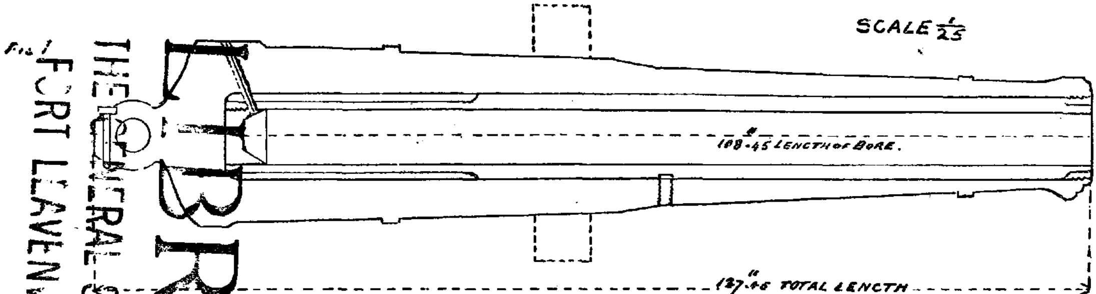
System of Conversion.—The system of conversion carried out was the same in all cases and was as follows. The cast-iron gun was bored out to a diameter of 10·5 inches; the muzzle being recessed and threaded ready for a cast-iron collar. A tube for insertion in the gun was formed by welding together longitudinally five wrought-iron coils, a forged iron cup being screwed into its breech end: the outer surface of this end of the tube was turned down for a length of 32 inches, and on it a spiral gas channel was cut, communicating with grooves on the back of the cup, and with a gas escape channel through the breech of the cast-iron gun.

A B tube having been shrunk over the turned down portion of the A tube, the whole, after being oiled, was fitted into the cast-iron casing; a collar was then screwed into the recess at the muzzle, the tube being further secured by a wrought-iron pin screwed in underneath through the outer casing. After firing proof charges the tube was permamently expanded into its casing. The calibre of all natures of converted guns is 6·3 inches.

Rifling.—The guns are rifled with the "plain groove" in the 64-pr. and with the Woolwich groove in 80-pr. guns; a uniform twist of 1 in 40 calibres and three grooves are employed.

Vents, &c.—Converted guns are through-vented with a copper-bush, the old vent inclined at 10° being used except in the 71-cwt. gun, in which case the old vent is plugged up and a new one bored.

64-PR. R.M.L. CONVERTED GUN OF 58 CWT.



40-PR. R.B.L. GUN OF 35 CWT (BREECH SCREW)

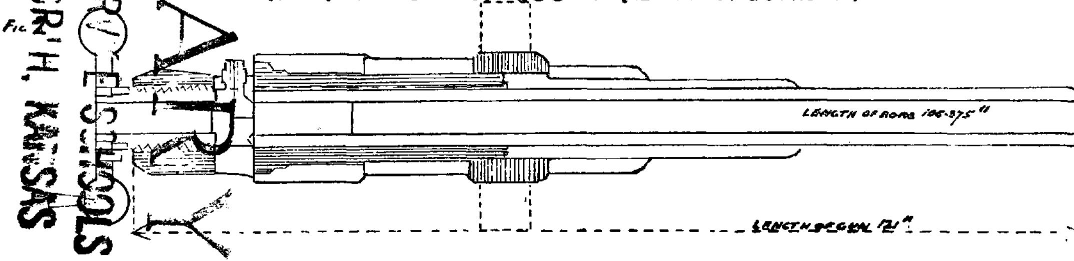


PLATE XII.

To face p. 46.

Lanyard guides are provided and clinometer planes cut on the breech, as for other natures of R.M.L. guns.

Sights.—64-pr. (58 cwt.) guns have central hexagonal gun-metal hind sights; the bar is graduated to 12° on its front face with a yards and fuze scale on the rear and right rear faces. The deflection leaf allows of 90 minutes right or left deflection.

The fore sight is of the drop pattern, and its socket is fixed in a bracket screwed to the gun. A fore sight is recessed into the dispart patch on the muzzle of the gun, for use at angles of elevation above 5°, the clearance angle. The deflection leaf being graduated for the short radius, allowance must be made when using the muzzle sight.

64-pr. (71 cwt.) and 80-pr. converted guns have tangent sights of the "B" pattern, that is without sighting blades; and a slow motion elevating nut for use up to 10 minutes is provided.

The hind sights of 64-pr. converted guns are set at an angle of 2° 16′ to the left, those for 80-pr. guns being 19 minutes.

Examination of Converted Guns.—The pieces are examined after each series of 150 rounds; impressions being then taken of the seat of the charge and of the joint of the cup at the breech.

Defective welds in the coiled barrel usually exist, but are of no consequence unless the defect is found to be extending circumferentially; and the depth of a flaw is usually more serious than its extent.

Employment of Converted Guns.—These guns have been used for many years past to provide an auxiliary fire for heavy guns mounted on sea fronts, and also for the land-fronts of fortresses. For such purposes they have proved very valuable pieces, on account of their good shooting qualities and their small cost.

They are now, however, being superseded by light or medium B.L. pieces and quick-firing guns, which are more suited to modern requirements.

§ Rifled Breech-Loading Guns (R.B.L.).

Construction.—R.B.L. Armstrong guns were introduced more than thirty-five years ago, being in most cases built up of wrought iron entirely, a few only having steel barrels.

Over an A tube made of wrought iron coils were shrunk a breech-piece (forged), a trunnion ring and B tube, and one or more additional coils according to the nature of gun.

A slot for the vent-piece was made on the top of the breech, with a circular aperture underneath; the interior of the breech-piece in rear being threaded for the reception of the breech screw.

The bore, which has a powder and shot chamber, is less in diameter in front of the seat of the shot than elsewhere; from this "grip," as it is termed, up to the muzzle the bore is slightly enlarged, thus easing the travel of the projectile.

The calibre measured at the "grip" is 4·75 inches in 40-pr. guns, 3·75 inches in 20-pr., 3 inches in 9 and 12-pr., and 2·5 inches in 6-pr.

Breech Mechanism.—The breech is closed by the vent-piece, which is a solid steel block retained in its position by a breech screw gearing in the gun; a gas-tight joint is secured by a coned copper ring on the vent-piece pressing into a breech bush of copper screwed into the gun.

Vent-Piece.—The steel vent-piece consists of a body, vent bush of copper in two parts, copper ring, cross-head and shackles or handles: 40-pr. and 7-inch guns have two, and lower natures one handle. A "beak" on the vent-pieces of 40-pr. and 7-inch guns protects the face of the copper. The vent channel passes through the vent-piece vertically and axially, the vertical portion being bushed with copper.

The copper ring of the vent-piece is pressed into an undercut groove on its front face, but 7-inch vent-pieces have no copper ring, a tin cup being used for obturating purposes.

Breech Screw.—The breech screw is a hollow cylinder of steel having a screw thread on its outer surface.

Tappet Ring.—This ring, which is octagonal, fits on the rear end of the breech screw, and with the lever acts as a wrench when screwing up and unscrewing the breech.

Lever.—The lever revolves freely on the breech screw in rear of the tappet ring, being retained in position by two keep pins sliding in a cannelure. A handle, weight ball, and a projection to act on the cam of the tappet ring are provided for levers of 20-prs. and under; two weight balls and two projections for 40-pr. and 7-inch, and an additional handle for 7-inch guns.

Indicator Ring.—This ring for 40-pr. and 7-inch guns is placed in front of the tappet ring, one of the grooves on its inner surface fitting over a feather on the breech screw; if properly adjusted it indicates when the vent-piece has been properly screwed up for firing: this is shown by the coincidence of a brass projection on its surface with a similar one on the breech screw.

System of Rifling.—The coating of soft lead on the projectile is cut into by the narrow lands of the gun, the lead being also compressed into the grooves, rotation is thus imparted. A polygroove system of rifling of uniform twist is employed.

Sights.—Side sights of ordinary pattern are used, except that 7-inch of 72-cwt. guns have hexagonal gun-metal sight bars.

TABLE IV.—R.M.L. CONVERTED AND R.B.L. GUNS.

Guns.	Mark.	Service: Land, Naval, or Common.	Nominal Weight.	Length of Bore in Calibres.	Total Length in Inches.	Muzzle Velocity. Foot Seconds.	Remarks.
CONVERTED GUNS.							
64-pr.	I.	L.	58 cwt.	17·24	127·45	1260	
„	I.	C.	71 „	16·42	122·72	1260	
80-pr.	I.	L.	5 tons.	18	136·55	1230	
R.B.L. GUNS.							
9-pr.	..	C.	6 cwt.	17·5	62	1055	
12-pr.	..	C.	8 „	20·46	72	1239	
20-pr.	..	N.	13 & 15 cwt.	14·43	66·125	1000	
„	..	L.	16 cwt.	22·36	96	1130	
40-pr.	..	C.	32 „	22·39	120	1160	
„	..	C.	35 „	22·39	121	1160	
7-inch .. .. .. (a)	..	L.	72 „	14·21	118	1100	(a) These guns have different size of chamber.
„ .. .. .. (a)	..	C.	82 „	14·21	120	1100	

Fittings.—A gun-metal saddle is fitted on the breech of 7-inch guns, for the support of the vent-piece when out of the gun; and for the 7-inch an iron lever is used to force out the vent-piece when necessary.

Side-Closing 40-pr. R.B.L. Gun.—For convenience, when mounted on high or parapet carriages, certain 40-pr. guns have been made side-closing by moving the trunnion ring a $\frac{1}{4}$ circle, so that the vent-piece slot is on the right side. The vent channel is then plugged up, and the breech block slides out of the slot between brackets; its movement being controlled by a spring stop actuated by a small lever. The gun is re-vented with a radial vent, 6·5 inches from the end of the bore, and at an angle of 45° on the right side of the gun.

Examination of R.B.L. Guns.—7-inch guns are examined after firing each series of 100 rounds; 40-pr. and lower natures after 150. The bearing surfaces of the face of the breech screw and back of the vent-piece should be tested with a straight-edge, and the fitting and facing of the copper ring and breech bush carefully examined.

Smooth-Bore Ordnance.

32-pr. S.B. Gun of 42 cwt. converted to B.L.—Certain 32-pr. S.B. guns have been altered to breech-loading, for use with case shot in caponnières, flanks, &c., of works. The ordinary breech block with interrupted screw is used, and a steel cup obturator, as described for B.L. guns.

The case shot of sheet iron, 12 inches long, with its front end coned, contains 730 mixed metal balls, 16 to the lb., the interstices being filled with clay and sand.

General Description of Smooth-Bore Ordnance.—Although S.B. ordnance, except the above converted piece, form no part of our armaments at the present time, yet until comparatively recently numbers existed in the service: they are, therefore, briefly referred to, and it is to be noted that for centuries they were the weapons which performed valuable service, and are the foundations on which modern ordnance have been raised.

S.B. Pieces.—The pieces consisted of guns, carronades, howitzers and mortars, cast in iron or bronze, and bored out. Their manufacture ceased about 1859. Subsequently, however, a few 100 and 150-pr. wrought-iron S.B. guns were made. Shell guns, howitzers and mortars were used for shell only; guns and carronades for solid shot.

32-pounders, of which about eleven descriptions existed, were the principal armament of vessels, those of 56 and 58 cwt. being used chiefly in land defences.

The 68-pr. iron gun, of 112 cwt., was the heaviest piece cast, but one of 95 cwt. was most commonly mounted.

The 8-inch shell gun, of 65 cwt., was a siege-train piece, and was also mounted in works. Mortars were short pieces for firing shells, usually at an angle of 45°, the charge being varied to suit the range. Howitzers were short pieces, being lighter than guns of the same calibre, and used for firing heavy shells with low charges.

The axis of the trunnions of guns and howitzers was below that of the piece, and the "preponderance," or excess of weight in rear of the trunnions, was great.

The trunnions of mortars were placed at the breech for convenience in high-angle firing, and with carronades a loop projecting below was used for attachment to the carriage in place of trunnions.

Bronze Ordnance.—The following were the bronze pieces employed: Guns, 6, 9 and 12-pounders. Howitzers, $4\frac{2}{5}$-inch, 12, 24 and 32-pounders. Mortars, $4\frac{2}{5}$ and $5\frac{1}{2}$-inch, Coehorn and Royal.

Cast-iron Ordnance.—The cast-iron pieces were · Guns, 9, 12, 18, 24, 32, 42-pounders, 8 and 10-inch shell guns, and 68-pounders. Carronades, 24, 32, 42 and 68-pounders. Howitzers, 8 and 10-inch. Mortars, 8, 10 and 13-inch, the latter of 36 and 100 cwt.

CHAPTER VI.

MACHINE GUNS.

Employment of Machine Guns.—Machine guns are employed in the service, with an army in the field, or in fortresses as an auxiliary means of defence against close attack, either on land or sea fronts, and for siege purposes; they are also used in all classes of vessels and for boat service. For the above uses their mountings are arranged to meet the special requirements of each. For field service, on account of convenience of ammunition supply, machine guns should fire the same cartridges as the infantry rifle; but for siege, fortress or for sea service, there is not the same necessity, and therefore for these purposes guns up to 1-inch calibre, and firing bullets up to a maximum weight of 14 oz., may be employed with advantage, in addition to smaller natures.

In machine guns mechanical devices are used for loading, firing and extracting the empty cases, so that a large number of fairly well-aimed rounds can be fired in a short space of time, whilst a small personnel only is employed.

Natures.—There are several natures of machine guns, which are distinguished by their calibre and the number of their barrels. They comprise those with 1, 2, 3, 5 or 10 barrels, having calibres of 0·303-inch, 0·4-inch, 0·45-inch, 0·65-inch and 1-inch. They also bear the names of their respective inventors, viz. Gatling, Gardner, Nordenfelt and Maxim.

GATLING GUNS.

Gun, machine, Gatling 0·45-inch, 10-barrel.
" " " 0·65-inch, "

The 0·45-*inch gun* weighs 402 lbs. The steel barrels are grooved with the *Henry-Martini* system of rifling; the M.H. chamber being applied to the newer guns of this nature. The ten barrels are supported round a central shaft fixed in a gun-metal frame, behind which the casing with the breech mechanism is attached. A worm wheel on the shaft gears with a worm on a

spindle, the latter having a crank handle, by which the main shaft and barrels are revolved; the system also permits of a lateral motion being imparted for spreading the bullets: at the same time the locks are pushed to the front or back, a cam or cocking ring actuating each firing pin in succession. A feeding drum rests on a hopper on the cartridge carrier on the main shaft. When in action the ten cartridges are in different stages of loading, firing and extraction.

The 0·65-*inch gun* weighs 787 lbs., and is for sea service, the mechanism being generally similar to the 0·45-inch gun.

Gardner Guns.

Gun, machine, Gardner 0·4-inch, 2-barrel.
" " " 0·45-inch, 1-barrel.
" " " " 2 "
" " " " 5 "

The 0·4-*inch gun* weighs 88 lbs. without shield or mounting, and the system of rifling used is the Enfield. The axes of the two barrels are parallel, their breech ends being fixed in the centre cross-piece of a frame, the hind portion of which is increased in depth to form the breech casing, containing the mechanism. The locks are pushed to the front or drawn back, by a disc crank furnished with a handle. A vertical cartridge feeder, which contains 30 cartridges, is supplied from cartridge holders. Some of these guns have been bored up to 0·45-inch calibre, and provided with the Henry system of rifling and the M.H. chamber.

The 0·45-*inch* 1-barrel gun weighs 59 lbs.; the 2-barrel 92 lbs., and the 5-barrel 268 lbs., the latter being used only for sea service. The 0·45-inch have similar mechanism to 0·4-inch guns, but the barrels are slightly longer. Shields 2′ × 2′ of 0·25″ inch steel plate are provided; the Henry system of rifling is used, with seven grooves and a twist of 1 in 22 calibres.

Nordenfelt Guns.

Gun, machine, Nordenfelt 0·45-inch, 3-barrel.
" " " " 5-barrel (Marks I. and II.).
" " " 1-inch, 2-barrel.
" " " " 4-barrel (Marks I., II. and III.).

0·45 *inch guns.*—The axes of the barrels of these guns are parallel, their breech ends being screwed into the cross-piece of a wrought-iron frame. The action block carrying the breech plugs and mechanism slides on the frame, behind the cross-piece. The lock is actuated by a lever, and at the forward motion the cartridges are pushed into the chamber of the barrels, and held by the breech plugs during discharge; by the back motion they are withdrawn by the extractor attached to the breech plugs. A hopper or magazine containing four columns, each holding ten cartridges, feeds the guns by the cartridge carrier which slides on the frame.

The 3-barrel gun is for land service, and weighs 103 lbs.; the 5-barrel is for sea service, Mark I. weighing 160 lbs., and Mark II. 143 lbs.

The Henry system of rifling is employed, with 7 grooves and a twist of 1 in 22 calibres.

1-*inch guns.*—The mechanism of the 1-inch guns is similar to that of the 0·45-inch. The 2-barrel gun weighs 180 lbs.; the 4-barrel, Marks I., II. and III., 426, 440 and 447 lbs. respectively. These guns are for sea service.

Maxim Guns.

Gun, machine, Maxim 0·45-inch, 1-barrel.
„ „ „ 0·303-inch „

0·45-*inch gun.*—The gun comprises a recoiling and non-recoiling portion, the principal parts of the latter being the barrel casing and breech casing; the barrel with its lock, to which a crank is connected, recoils about 1 inch on firing. During recoil a projecting arm actuates a spring which pushes the recoiling part back again into the firing position, and causes a crank to act on the firing locks; the force of recoil is thus utilised for loading, firing and extracting the empty cartridge cases. The barrel, being surrounded by water in the casing, is kept cool. The gun is attached to its mounting by joint pins, the elevating gear and rear pin being connected.

The cartridges are fed to the gun from a tape band, which also holds them in the ammunition boxes.

The 0·45-inch gun for land service weighs 60 lbs.; it has the Martini-Henry chamber, is provided with sights, and is mounted on a parapet carriage.

The 0·45-inch for sea service has the Gardner-Gatling chamber; it is provided with a shoulder piece and gun shield, and is mounted on a Maxim cone mounting.

The 0·303-*inch gun* is very similar to the 0·45-inch in its action, but uses 0·303-inch ammunition. To ensure a working recoil when firing blank, a blank firing apparatus is screwed to the muzzle, the latter being threaded for the purpose; when not in use it is replaced by a muzzle protector.

The gun is for land service, and is mounted for field or garrison purposes as required; it weighs 60 lbs.

Ammunition for Machine Guns.

The following are the cartridges respectively used:—

For 0·303-inch guns, "Cartridge, S. A. ball, 0·303-inch, cordite (Mark II.)": the bullet weighs 215 grains, and the charge is made up of strands of cordite, size $3\frac{3}{4}$.

For 0·4-inch guns, "Cartridge, m. g. ball, 0·4-inch, Mark I."

For 0·45-inch guns having Martini-Henry chambers, the Martini-Henry cartridge with solid case.

For all other 0·45-inch guns, "Cartridge, m. g. ball, 0·45-inch, Mark IV.," which has a black powder charge; or the "Cartridge, m. g. ball, 0·45-inch, cordite (Mark I.)." In the latter case the charge consists of about 38 grains of cordite strands, size 3, the weight of the bullet being 480 grains.

For 0·65-inch Gardner guns a special cartridge is used.

For 1-inch Nordenfelt guns, "Cartridge, m. g. Nordenfelt, 1-inch, steel (Mark VI.)." The steel bullet, weighing 7·25 ounces, is covered to the shoulder with a solid drawn brass envelope, which imparts rotation; and the powder charge consists of 612 to 638 grains of M. G. powder, pressed into a pellet. The cartridge case is of solid drawn brass, with a cap chamber and anvil formed in the base; the length of the cartridge with bullet attached is 5 inches, and its weight 11·25 ounces.

Mountings for Machine Guns.

The following are the land service mountings for machine guns.

Gatling Guns.—The 0·45-inch is mounted on a field travelling carriage.

Gardner Guns.—The 0·45-inch 2-barrel gun is provided with a machine gun parapet carriage, or an infantry field machine gun carriage.

Nordenfelt Guns.—The 3-barrel Nordenfelt can be mounted on a machine gun parapet carriage, and also on an infantry field machine gun carriage.

Maxim Guns.—For 0·303 inch and 0·45-inch guns the "carriage, field, machine gun, cavalry or mounted infantry, Maxim," and the "carriage, field, machine gun, infantry, Maxim" are provided; and the "carriage, parapet, machine gun, Maxim" for 0·45-inch guns in addition.

Description of Mountings.

The *Cavalry Field Carriage* carries 3500 rounds of 0·303 or 2100 of 0·45-inch ammunition, in 14 boxes. A top carriage is fitted to the body, and, being movable on a curved base-plate, permits of the gun being fired either with the shafts of the carriage on the ground or with horses hooked in. The height of the axis of gun is 60 inches, and the weight of the carriage and ammunition without the gun is 8 cwt. 3 qrs. 2 lbs.; the wheel track is 62 inches.

The *Infantry Field Carriage* is very similar; and carries 4000 rounds of 0·303-inch or 2400 of 0·45-inch ammunition, in 16 boxes. Mule or manual draught is used. The height of the axis of the gun is 39 inches, wheel track 54 inches, and the weight of the carriage and ammunition without the gun is 6 cwt. 2 qrs. 10 lbs.

The *Parapet Carriage* consists of a pivot socket, axle-tree and wheels, cross-head, and stem. The stem with cross-head is made to lean against the parapet at any convenient part; and the stem has a rack, by which the carriage, consisting of the pivot socket, axle-tree and wheels, can be run up to a position for firing over the parapet by turning the right wheel. The gun and carriage when run down can be moved about on wheels as required.

For sea service, machine guns are mounted on tripod, gunwale or cone mountings. Mountings of this description can also be fixed in selected positions in works when necessary.

CHAPTER VII.

EXPLOSIVES, CARTRIDGES, ETC.

GUNPOWDER.

Composition.—All the natures of gunpowder in the British service, which are for the most part manufactured at Waltham Abbey, formerly contained 75 parts of saltpetre, 15 of charcoal, and 10 of sulphur. In the case of the slow-burning prismatic powders introduced, viz. Prism[1] brown, E.X.E. and S.B.C. powders, these proportions have been changed, principally in there being less sulphur.

The three ingredients are intimately mixed together to form gunpowder, which is an explosive mixture; no chemical action taking place in its manufacture, as with an explosive compound such as gun-cotton, nitro-glycerine, &c.

Saltpetre or Nitrate of Potash ($KONO_3$) contains 54 parts of nitric acid and 46 parts of potash, and is found in its natural state in hot climates, and can be produced artificially. Its use in powder is to supply oxygen, since it contains in one volume as much as exists in 3000 volumes of atmospheric air.

Sulphur (S).—This element is obtained in an uncombined state in volcanic districts, and is also found combined with iron, copper and other metals. It inflames at a temperature of 560° F., and owing to this inflammability it facilitates the ignition and accelerates the combustion of gunpowder. It probably also renders powder more durable and less hygroscopic. When the proportion of sulphur is less, as in the case of some prismatic powders, the powder is slower burning.

Charcoal (C) acts as the fuel of powder, and is the residue which remains after wood or vegetable fibre has been charred. By the process of charring, moisture and other volatile parts are driven out, and the charcoal then approximates to pure carbon. Pure charcoal produces a slow burning and less combustible powder, whereas slack or red-burnt charcoal creates a violent powder, which absorbs moisture readily, and is liable to deteriorate in strength. The straw charcoal used for brown powder is carbonised by a special process.

Properties.—When gunpowder is heated to a temperature of about 600° F., the oxygen of the saltpetre combines violently with the carbon to form carbonic acid and oxide; these with free nitrogen form the gaseous products. The solid products consist of potassium in combination, viz. carbonate and sulphate of potash, and sulphide of potassium, which are in a fluid state shortly after firing, and serve to maintain the temperature of the gases, but they produce fouling in the gun and cause smoke.

The products of explosion are expressed in the official treatise on explosives by the following equation :—

$$\underset{\text{Mixture forming Gunpowder.}}{16KNO_3 + 21C + 5S} = \underset{\text{Solid products.}}{(5K_2CO_3 + K_2SO_4 + 2K_2S_2)} + \underset{\text{Gases.}}{(13CO_2 + 3CO + 8N_2)}$$

The temperature of explosion of powder is 2000° F., and the tension 42 tons per square inch when the powder entirely fills the vessel in which it is fired (Noble and Abel). About 20 tons per square inch is the maximum pressure allowed in the bore of any gun. The chief advantages of powder beyond those possessed by other explosives are, that it is comparatively safe to manufacture, to store, or to move about with proper precautions, also its "explosiveness" or rate of burning can be regulated. The latter depends principally upon the density and size of grain, and to a lesser extent on the shape, degree of hardness, and amount of glaze imparted to each grain; but moulded powders are not glazed.

In B.L. guns, owing to the driving band on the projectile being larger than the bore, a very slow burning powder can be used, since a pressure of one to two tons on the square inch is necessary before the projectile commences to move.

Density and Size of Grain.—The time taken by a grain of powder to burn is longer in proportion as its density increases; and again, a given weight of powder composed of say 30 grains or pieces will burn more quickly than the same quantity composed of 10 pieces, owing to the larger amount of surface for ignition in the first case.

A powder charge for heavy guns is composed of large grains of high density and of a regular shape, the surface for ignition being increased by axial perforations through each grain, so that a high rate of ignition but slow rate of combustion is obtained; and the combustion of such slow-burning powder causes a force to be exerted on the base of the shell corresponding to a push sustained throughout its travel up the bore.

Gravimetric Density.—This is the density of a charge of powder and of the air space in the chamber it occupies; so that

practically it is the ratio between the weight of powder and the weight of water completely filling the space behind the projectile.

Since 1 lb. of water occupies 27·73 cubic inches, and 1 lb. of P. powder, for example, 24 cubic inches normally, a charge of 100 lbs. of P. powder having a density of $\left(\frac{34\cdot4}{0\cdot806}\right)$ means that the space behind the projectile (powder chamber) in cubic inches divided by 100 (pounds of powder), that is 34·4, is the space which each pound of powder occupies; and the ratio of this number to 27·73 gives the gravimetric density 0·806.

Number of Expansions, &c.—It was originally considered that the length of a charge of powder in a gun should not exceed $3\frac{1}{2}$ times its diameter, otherwise abnormal strains or "wave action" were produced; also by further increasing the length of a charge the bore is reduced, and the possible number of expansions of the powder charge diminished; and so the total work on the base of the projectile which the powder charge is capable of doing. To obviate these disadvantages without lessening the charge, "chambering" is resorted to, and that portion of the bore in which the charge lies has an increased diameter (see also page 18).

Moisture.—All powders contain about 1·3 per cent. of moisture, and it is important that the amount should remain constant; when there is an excess the strength of the powder is lessened, and there is loss of range. Moreover an excess of moisture will in time render the powder unserviceable, bright crystals of saltpetre being seen on the grains. Certain appliances are issued to firemasters to test the quantity of moisture in black powders, and when the amount exceeds 1·3 per cent. the powder is reduced in class. It is indispensable that powder should be kept in dry magazines, and filled cartridges in air-tight cases.

Natures of Gunpowder.

The following are the "natures" of gunpowder in use in the land or sea service, with their nomenclature.

Moulded Gunpowders.

Gunpowder, Prism[1] *Black.*—Made of grains pressed into hexagonal prisms 0·98 inch in height, and 1·38 inch in diameter over the sides; in each grain there is an axial perforation 0·4 inch diameter; the density is 1·76; used for 8-inch, (Marks III.

and VII.) B.L. guns, and 12·5 and 17·72-inch R.M.L. guns, but is superseded by E.X.E. powder.

Gunpowder, Prism[2], differs from prism[1] black in size; the grains are hexagonal prisms 2 inches in height and 2·35 inches in diameter, with an axial perforation of 0·575 inch; the density is 1·75 inch; used for 12·5-inch Mark II. and 17·72-inch R.M.L. guns, but is superseded by E.X.E. powder.

Gunpowder, Prism[1] *Brown.*—The prisms are similar to prism[1] black; the density is 1·8. It contains 79 per cent. saltpetre, 3 per cent. sulphur, 18 per cent. straw charcoal, which is slack or red burnt and gives the brown colour to the grain. It is slow and regular in its action, and gives less smoke than black powder; used for 8-inch (Marks IV. and VI.), 10-inch, 9·2-inch and 12-inch B.L. guns, also for 16-inch R.M.L. guns.

Gunpowder S.B.C.—The grain of this slow-burning cocoa powder is similar in external appearance to prism[1] brown, but to distinguish it one face of each prism is marked with a circular indentation 0·8 inch in diameter; the density is 1·85: it is used for 13·5-inch and 16·25-inch B.L. guns.

Gunpowder E.X.E.—The grain is similar in shape to the above, but is dark slate coloured, and to distinguish it from other prismatic powders one face of each prism is indented with a ring $\frac{1}{10}$-inch in breadth, 1 inch external diameter; the density is 1·8. It will replace P[2], prism[1] black and prism[2], and is used for 6-inch B.L. guns when using powder charges.

All the above powders are packed in 100 lb. wood cases, zinc lined.

Cubical Powders.

Gunpowder P.[2]—The grains of this pebble powder are $1\frac{1}{2}$-inch cubes, 5 to 7 to a pound; the density is 1·75; used with 6-inch (Marks II. and III.) B.L., and 12, 12·5-inch (I) R.M.L. guns. It will be superseded by E.X.E. powder.

Gunpowder P.—The grains of this pebble powder are $\frac{5}{8}$-inch cubes, 80 to the pound; the density is 1·75; used with 80-pr. to 12-inch R.M.L. guns inclusive.

Gunpowder S.P.—This is P. powder, specially selected and blended to form a powder uniform in its action; used for 12-pr., 20-pr. 4 and 5-inch, and 80-pr. B.L. guns, and also for all cartridges for which P powder is used but is not available.

Gunpowder Q.F.[1]—The grain is $\frac{1}{2}$ inch square by $\frac{3}{10}$ inch thick; the density is 1·75; used for 3 and 6-pr. quick-firing guns.

The above cubical powders are packed in waterproof bags in barrels containing 125 lbs., and 110 lbs. in the case of Q.F.[1] powder.

Granulated Powders.

Gunpowder R.L.G.[4]—The size of grain is 2 to 3 mesh, that is the grain should pass through a sieve of 2 but not of 3 meshes to the linear inch; its minimum density is 1·65; used principally for medium R.M.L. guns; it is slower burning than R.L.G[2].

Gunpowder R.L.G.[2]—The grain is smaller than R.L.G.[4], viz. 3 to 6 mesh; the minimum density is 1·65; used up for R.M.L. field guns, and in place of R.L.G.[4] for land service only.

Gunpowder R.L.G.—The size of grain is 4 to 8 mesh; the minimum density is 1·7. This powder is no longer made, being superseded by R.L.G.[2]

Gunpowder L.G., or large grain, is no longer made; but was formerly used for all ordnance; it is used up for S.B. guns and for filling R.M.L. land service shells in some cases.

Gunpowder M.G.[1]—The size of grain is 7 to 14 mesh; the minimum density is 1·75; the grains are compressed into a pellet and used for 1-inch Nordenfelt machine guns.

Gunpowder R.F.G.[2]—The size of grain is 12 to 20 mesh; the density is 1·72 to 1·75; it is a slower burning powder than R.F.G., and is used for the M.H. rifle and rifle-calibre machine guns.

Gunpowder R.F.G.—The grain is similar in size to R.F.G.[2]; its density is 1·6; it is used for the Snider rifle and for the 7-pounder of 200 lbs.

Gunpowder Rifled Pistol.—The size of grain is 20 to 36 mesh; the density is 1·58 to 1·65; it is made from the siftings of R.F.G.

All the above granulated powders are packed in waterproof bags in barrels containing 100 lbs., or in the case of R.L.G.[4] and R.L.G.[2] powders 110 lbs.

Classification of Gunpowder.

Gunpowder is classified as to its use as follows:—

Class I. Service.—Includes all descriptions of powder used for firing projectiles; and consists of new powder or that which on examination has been found fit for service, and also of powder that has been repaired.

Class II. Blank.—Includes powder from broken-up cartridges not fit for Class I., and of service gunpowder found dusty or broken in grain and not repairable; also of powder specially made for blank firing.

The only powders that would usually be placed in this class are L.G., R.L.G., R.L.G.^{2}, R.L.G.^{4}, which are then designated Blank L.G.; or R.F.G., R.F.G.^{2}, designated Blank F.G.

Class III. Shell.—Shell P. and shell Q.F. include powder specially selected for P. mixture for filling common shell, or of service P. or Q.F. powder found on examination to have become slightly dusty but not containing moisture in excess of 1·45; shell L.G includes service gunpowders L.G., R.L.G., R.L.G.^{2}, R.L.G.^{4}, found dry but dusty, or soft but broken in grain; shell F.G. includes F.G., R.F.G., R.F G.^{4}, powders when reduced in class. Gunpowder "Q.F. shell" F.G. is specially made for filling 3 and 6-pr. shells; Class I. service powder is used for filling shrapnel shell.

The above three classes are known as *serviceable* powders.

Class IV. Doubtful.—Includes all powder awaiting examination.

Class V. Condemned.—Includes powder fit only for mining, blasting, or for sale.

Class VI. Condemned for Extraction.—Includes powder obtained from shell and from small arm ammunition or other cartridges or charges which contain their own means of ignition; this powder is wetted (3 gallons of water to a barrel), excepting that P. powder obtained from shell is sifted, and if serviceable is retained as shell powder; powder obtained from quick-firing ammunition is dealt with similarly.

Mealed Powder is ordinary powder reduced to an impalpable dust; it ignites easily and burns rapidly, and is used in quick match, portfire composition, friction tubes, &c.; it is passed through an 120-mesh sieve.

Pit-mealed Powder is so called on account of the charcoal having been prepared in pits in place of cylinders; it is used in fuze composition on account of its regularity of burning.

Gun-Cotton.

Gun-cotton is an explosive compound formed by the action of nitric acid on pure cotton (cellulose); strong sulphuric acid is mixed with the nitric acid to render it stronger by removing the water. The chemical change that occurs in manufacture is the following:—*

$$\underset{\text{Cellulose.}}{C_6H_{10}O_5} + 3\underset{\text{Nitric acid.}}{(HNO_3)} = \underset{\text{Gun cotton, or trinitrate of cellulose.}}{C_6H_7O_2 \cdot 3NO_3} + \underset{\text{Water.}}{3H_2O}.$$

* Treatise on Service Explosives.

When fired the products of explosion are gaseous, being chiefly carbonic acid and oxide, nitrogen, and water vapour.

$$2(C_6H_7O_2) \cdot 3NO_3 = 9CO + 3CO_2 + 7H_2O + N_6.*$$

Gun-cotton is manufactured in a wet state, the wet pulp to which it is reduced being moulded, and afterwards pressed into discs or slabs weighing from 1 oz. to $2\frac{1}{2}$ lbs.; holes are bored in the latter to receive primers of dry gun-cotton or detonators. Compressed gun-cotton is also cut or turned into the shapes required for torpedo charges or for mines.

Gun-cotton is stored and used in a wet state, containing, that is, at least 20 per cent. of water; it is then perfectly safe, being incombustible. By using, however, a primer of dry gun-cotton, wet compressed gun-cotton can be detonated in an unconfined state; the dry primer being detonated by fulminate of mercury.

Dry gun-cotton inflames at a temperature of 300° F., and detonates easily by percussion; it is used in the service for primers or discs of 1, 2 and 9 ounces or $1\frac{1}{2}$ lbs., which are packed in copper or tin cylinders. It is also occasionally used in the form of yarn as a priming for time fuzes.

Wet gun-cotton is stored in wood cases having a copper-tinned inner case, containing 50 lbs.; or in submarine mines or countermines when stored charged; or in cases containing charges of outrigger and Whitehead torpedoes.

Gun-cotton is used for destroying bridges, lines of railway, stockades, and for disabling guns, and also for submarine mines and torpedoes. It also enters largely into the composition of cordite.

For rules as to examination of gun-cotton, see Magazine Regulations; and for tables of forms of gun-cotton in use, List of changes in war matériel (4883).

Cordite.

This explosive compound consists of 58 per cent. of nitroglycerine, 37 per cent. of gun-cotton, and 5 per cent. of mineral jelly. It is so called on account of its similarity to pieces of cord.

The products of explosion of cordite are all gaseous, consequently no fouling in the bore takes place when it is used as a charge, and there is practically no smoke. It possesses also another great advantage over gunpowder in that smaller charges can be used, and the maximum chamber pressures are lower;

* 'Dictionary of Explosives' (Cundill).

whilst at the same time higher muzzle velocities are obtained than with powder, owing to the pressure being more sustained.

Cordite is designated by its size in hundredths of an inch. This is regulated by the diameter of the die through which it is pressed in manufacture. It is made in sizes from $3\frac{3}{4}$ up to 50 hundredths of an inch, and is cut into cords or sticks measured in inches.

Thus cordite size $\frac{50}{16}$ means that each piece has a diameter of $\frac{50}{100}$ inches and a length of 16 inches. The composition of all sizes is the same, but the rate of combustion decreases as the size increases. Cordite contains no moisture, and its density is 1·56.

The nitroglycerine, of which it is largely composed, is formed by the action of nitric acid on glycerine, just as the acid acts on cotton to form nitrocellulose, or gun-cotton. Nitroglycerine, when mixed with a porous earth to render it less sensitive, is known as "dynamite."

Cordite is now used in the service for small-arms, machine and quick-firing guns, and all breech-loading guns.

It is packed in 70 and 100-lb. wood cases.

The following are the sizes in use in the service:

Size, $3\frac{3}{4}$, $\frac{5}{12}$, $\frac{7\frac{1}{2}}{12}$, $\frac{10}{7}$, $\frac{10}{12}$, $\frac{15}{14}$, $\frac{20}{17}$, $\frac{30}{24}$, $\frac{40}{25}$, $\frac{50}{16}$ (7279, 8536).

Lyddite.

This explosive is used for the bursting charge of shells in certain cases (8456). It burns very rapidly, or detonates, and is therefore more suitable than powder for the charge of a shell, producing a higher destructive effect.

It is picric acid brought into a dense state by fusion. Picric acid is obtained by the action of nitric acid on phenol or carbolic acid.

Picric powder is a mixture of ammonium nitrate and saltpetre, and is used as an exploder for shells filled with lyddite.

Cartridges, Filled and Empty.

A charge, whether of powder or cordite, used with any piece of ordnance is made up of one or more cartridges. In the case of R.M.L. ordnance one cartridge only is used to make up a complete charge, whether full or reduced, except in the case of 6·6-inch,

9-inch, 10·4-inch, 12·5-inch, 16-inch, and 17·72 inch guns. In B.L. guns the charge is made up of two or more cartridges, except 4-inch guns and under, when one cartridge only is used either for the full or reduced charge. The charge of a gun is either "Full" or "Reduced," and for smaller natures there is also a "saluting" charge. A reduced charge may comprise a certain number of the cartridges forming the full charge: thus the reduced charge of the 16·25-inch B.L. gun is four or six cartridges, the full charge being eight.

The material of which an empty cartridge is made is silk cloth, classified according to its strength. Class I. is used up to 14 lbs., Class II. for cartridges 14 to 85 lbs., and Class III. for all cartridges of prism powder and for others above 85 lbs.

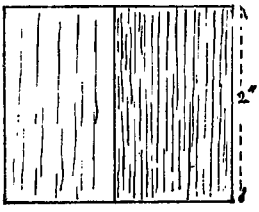
Serge was formerly used, and the stock may be used up for R.M.L. cartridges (to 85 lbs.), for S.B. and R.B.L. cartridges, except the 40-pr.; in all cases when firing blank, silk cloth must be used. Serge cartridges are not issued for sea service (6317). Red shalloon is made use of for 4-oz. and 6-oz. charges of 7-pr. and 2·5-inch R.M.L. guns, and for primers for common shell or for powder puffs.

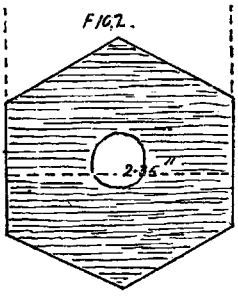
A cartridge material should leave no smouldering residue in a gun after firing; it should be of strong texture, and in the case of forward vented guns it was necessary that it should be permeable to the flash of the tube.

Filling Cartridges.—In filled cartridges containing cubical or granulated powders, the mouth of the cartridge is choked with silk twist, or worsted for serge cartridges; the shape being preserved by hoops of silk braid, or worsted in the case of serge. Lifting beckets of silk braid are attached to 30-lb. cartridges and upwards.

When filling cartridges with prism powder, the prisms are built up inside a zinc envelope attached to a wooden base of the same sectional area as the cartridge.* A fixed number of layers are built up, and the exact weight finally obtained by altering the number of prisms in the top layer. In the case of slow-burning brown powders, seven or ten prisms of black powder are inserted in the top and bottom layers. The empty cartridge with the bottom sewn on is then drawn over the envelope; the latter being then drawn through, cartridge reversed, and the top securely sewn on with sewing silk. In the centre of the top and bottom of these cartridges there are apertures covered with network, to facilitate ignition, and patches of shalloon fixed with shellac, to prevent any powder dust from shaking out.

* A cartridge can be more expeditiously filled without the zinc envelope, two or three men building up the prisms on the wooden base, the empty cartridge being cased over.





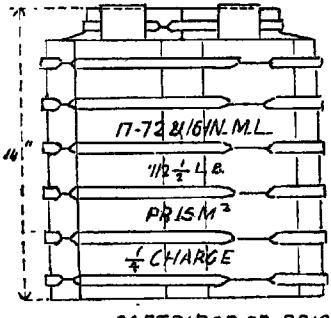
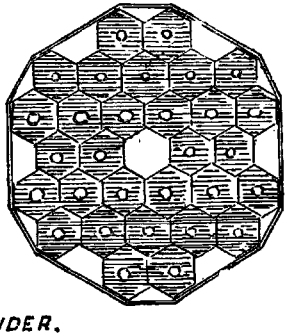


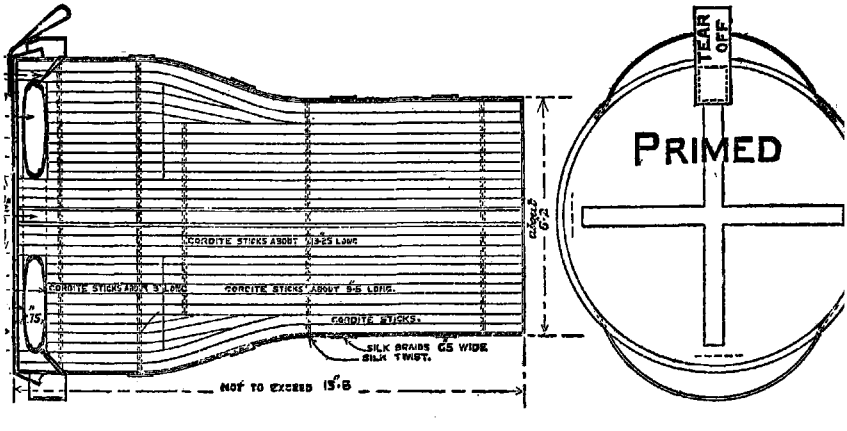
FIG.3.

1/10



CARTRIDGE OF PRISM² POWDER.

Cartridge, B.L., 10-inch, 19-lb., cordite, size 30. Silk cloth ¼-charge.



12-inch B.L. cartridges and upwards have an inside lining of silk cloth for additional strength, in which case the ends are also in two thicknesses.

Great care is necessary to ensure an empty cartridge being thoroughly dried before filling; and the fact is sometimes overlooked that the empty cartridge must be exclusive of the weight of powder used.

It has been found that 13 men in a laboratory work-room can fill 24 120-lb. cartridges (representing three full charges) of a 16·25-in. B.L. gun, in 8 to 9 hours; this includes packing and marking the cases, &c.; additional men and transport according to circumstances being required outside between the work-room and the magazines. It is an absolute essential that the air in the laboratory should be perfectly dry, the room being artificially heated if necessary, when filling cartridges.

Cordite Cartridges.—These cartridges are made of silk cloth hooped with silk braid, with lifting beckets at either end. The sticks of cordite are laid lengthways, and at one end an annular space is left for a primer of R.F.G.^{2} powder, contained in a ring of shalloon and silk cloth.

A disc of silk netting closes the cartridge; a millboard disc, which is removed before loading, being placed for protection.

With howitzer cartridges rings of cordite encircle a central core, the rings being removed as required to regulate the weight of the charge.

R.B.L. Cartridges.—These have a lubricator inserted in the front end, or screwed into a wooden socket choked in; the lubricator consists of two tinned iron cups soldered together, and containing a mixture of tallow and linseed oil, attached to a felt wad and millboard disc; its object is to prevent the lead coating of the projectile choking the grooves. A varnished paper cylinder is also placed in 20-pr. to 7-inch R.B.L. cartridges, to bring them up to the length of the powder chamber.

Cartridges with Sticks.—Cartridges for 12·5-inch R.M.L. guns have a varnished stick through their length, the cartridge being choked round it at either end; a special apparatus is provided for filling.

Marking Cartridges.—Cartridges are marked before filling with their nature; printers' ink, not paint, being used.

Gauging Cartridges.—Ring gauges are used to test the diameter, and a universal gauge the length of cartridges.

Designation of Cartridges.—Cartridges may be "filled" or "empty." The following are examples of the service method of designating any particular cartridge:

"Cartridge, R.M.L., 12·5-inch empty (or filled) silk cloth,

47½ Prism[1] black (Mark I.)," or "cartridge B.L. 8-inch 7 lb. 3 oz. cordite. size 20 (Mark I.)."

Drill Cartridges.—These consist of wood blocks covered with raw hide and having lead in the centre; their weight corresponds to that of the Service cartridges they represent.

Cases, Cylinders and Barrels used for Gunpowder and Filled Cartridges.

Cases for Storing Gunpowder.—When not made up into cartridges, gunpowder is packed for store or transport as follows:—All moulded or prism powder in *wood powder cases, zinc lined*, containing 100 lbs. The dimensions of the case are 29·85 inches × 15·5 inches × 9·125 inches, and the tonnage 0·06 ton. The case is painted red outside and the zinc lining is coated with copal varnish; packing pieces varnished with shellac are used as required to fill up the empty spaces in the case. Weight 47 lbs.

Marking.—All barrels or cases containing powder are stencilled with the maker's name, nature of powder, and the "Lot."

Powder Barrels.—Barrels are used for granulated or cubical powders, the powder being enclosed in a waterproof bag; the barrels are made of oak with copper and ash or hazel hoops; whole, half and quarter barrels are used. A whole barrel contains 125 lbs. of cubical powder, excepting Q.F.[1] powder 110 lbs.—and 100 lbs. of granulated powders, except R.L.G.[4], and R.L.G.[2] 110 lbs. The dimensions of a whole barrel are 21·1 inches × 17·1 inches, and its tonnage 0·089 ton. Barrels are stored on their bilges.

The capacity of a powder magazine is measured by the number of barrels it will contain, which may be as much as 9000 to 10,000 barrels. Proper means of ventilation are essential in all magazines and cartridge stores. A wet and dry bulb thermometer for reading the moisture of the external air is hung up outside all magazines, and a hard and fast rule varying with localities should be laid down as a guide for opening or closing ventilators, the inside temperature of the magazine being also considered.

Storing Filled Cartridges.

In Field and in some cases Siege artillery service, filled cartridges are placed in *Covers, cartridge paper*, when stored in the ammunition boxes. A portable magazine of leather is used when necessary for 3 cordite cartridges and 3 shells with 12 and 15-pr. guns.

Otherwise, for all ordnance up to but not including 7-inch,

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TABLE VI.—WEIGHTS OF FULL CHARGES AND PROJECTILES OF R.M L. AND R.B.L. ORDNANCE.

R.M.L. Ordnance.	Mark.	Full charges.			Weight of Projectile.	Natures of Projectiles used with R.M.L. and R.B.L. Ordnance.
		Powder.	Cordite.			
Guns.		lbs.	Size.	lbs. oz.	lbs.	
7-pr. (200 lbs.) ..	II.	½ R.F.G.[2]				*Palliser Shot, studless,* are used with 9 to 17·72-inch R.M.L., and also with 6·6-inch and 80-pr. (80-cwt.) guns. *Studded* Palliser Shot exist and are used up with 7 to 12·5-inch, except 10·4-inch and 9 and 10-inch high-angle fire guns. *Case Shot* are used in the land service with all R.M.L. guns and howitzers, except the 9 and 10-inch high-angle fire guns. *Pointed* common shell, with 8 to 12·5-inch R.M.L. guns. They are studless and of cast steel, made with a point and have a base fuze hole. *Common Shell, studded* and of cast iron, were made and are used up with 7-pr. to 12·5-inch guns, except 10·4-inch, 9 and 10-inch high-angle fire guns, 80-pr. (80-cwt.), 15-pr., 13-pr. and 2·5-inch guns. *Common Shell, studless,* of iron or cast steel, are used with 9 to 17·72-inch R.M.L. guns, except 10-inch high-angle fire guns, and also with 80-pr., 6·6-in., 15-pr., 13-pr. and 2·5-inch guns, and with all R.M.L. howitzers. *Common Shell, filled with lyddite,* of forged steel, is used with 10-inch high-angle fire guns. *Shrapnel Shell, studded* and of iron, are used up with 7-pr. to 12·5-inch guns, except 10·4-inch, 9 and 10-inch high-angle fire guns, 6·6-inch, 80-pr. (80 cwt.), 15-pr., 13-pr. and 2·5-inch guns. *Shrapnel Shell, studless,* of cast iron or cast steel, are used with 9 to 17·72-inch R.M.L., except 10-inch high-angle fire guns, and also with 6·6-inch, 80-pr. (80 cwt.), 15-pr., 13-pr. and 2 5-inch R.M.L. guns, and with all R.M.L. howitzers. *Double Shell* are used with 7-pr. and 7-inch R.M.L. guns. *Star Shell* are used with 2·5-inch guns and all R.M.L. howitzers. *Ring Shell,* with 2·5-inch R.M.L. guns. R.B.L. Guns. Common and segment shell, of iron and lead-coated, are used with 9-pr. to 7-inch R.B.L. guns, and shrapnel shell with 9 and 12 and 40-pr. guns.
7-pr. (150 lbs.) ..	III.	¾ or				
„ (200 lbs.) ..	IV.	¾ R.F.G.				
2·5-inch	I., II.	1 9/16 R.L.G.[4] or 1½ R.L.G.[2]	..	..	7¼	
9-pr.	I. to IV.	1½ or 1¾ R.L.G.[2]	..	..	9	
13-pr.	I., II.	3¼ R.L.G.[4]	..	..	13	
16-pr.	I.	3 3/16 R.L.G.[4]	..	..	16	
25-pr.	I.	4½ R.L.G.[4]	..	..	25	
40-pr.	I., II.	6¾ R.L.G.[4]	..	..	40	
64-pr. (converted) ..	..	8¼ R.L.G.[4]	..	..	65	
64-pr.	I. and II.	6½ R.L.G.[4]	..	..	65	
„	III.	10 R.L.G.[4]	..	..	65	
80-pr. (converted) ..	I.	12 P.	..	..	90	
80-pr. (80 cwt.) ..	I.	20 P.	..	..	90	
6·6-inch	I.	25 P.	..	..	100	
7-inch (90 cwt.) ..	I.	22 P.	..	..	115	
„ (6½ tons) ..	I. to III.	30 P.	..	..	115	
„ (7 tons)	I. to IV.	30 P.	..	..	115	
8-inch	I. to III.	35 P.	..	..	180	
9-inch	I. to V.	50 P.	7½	13 4	256	
„	VI.	50 P.	..	..	256 and 360	
10-inch	I., II.	70 P.	10	20 6	410	
„	III.	..	..	..	..	
10·4-inch	I.	190 Prism[1] black	..	..	462	
11-inch	I., II.	85 P.	10	25 4	548	
12-inch (25 tons) ..	I., II.	85 P.	10	22 4	614	
„ (35 tons) ..	I.	110 P.	..	..	714	
12·5-inch	I.	165 Prism[1] black or Prism[2]	10	24 0	818	
„	II.	200 E.X.E.	10	29 8	818	
16-inch	I.	450 Prism[1] brown	..	..	1700	
17·72-inch	I.	450 Prism[1] black or Prism[2]	..	..	2000	
Howitzers:						
4-inch	I.	1¼ R.F.G.[2]	..	..	20	
6·3-inch	I.	4¼ R.L.G.[4]	..	..	70	
6·6-inch	I., II.	5 R.L.G.[2]	..	..	100	
8-inch (46 cwt.) ..	I.	10 R.L.G.[2]	..	..	180	
„ (70 cwt.) ..	I., II.	11½ R.L.G.[2]	..	..	180	
R.B.L. Guns:						
9-pr.	..	1¼ R.L.G.[2]	..	..	8½	
12-pr.	..	1½ R.L.G.[2]	..	..	11½	
20-pr.	..	2½ R.L.G.[2]	..	..	22	
40-pr.	..	5 R.L.G.[2]	..	..	40	
7-inch	72 cwt.	10 R.L.G.[2]	..	..	100	
„	82 „	11 R.L.G.[2]	..	..	100	

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TABLE VI.—WEIGHTS OF FULL CHARGES AND PROJECTILES OF R.M L. AND R.B.L. ORDNANCE.

R.M.L. Ordnance.	Mark.	Full charges. Powder.	Cordite. Size.	Cordite. lbs. oz.	Weight of Projectile.	Natures of Projectiles used with R.M.L. and R.B.L. Ordnance.
Guns.		lbs.			lbs.	
7-pr. (200 lbs.) ..	II.	½ R.F.G.[2]				*Palliser Shot, studless,* are used with 9 to 17·72-inch R.M.L., and also with 6·6-inch and 80-pr. (80-cwt.) guns. *Studded* Palliser Shot exist and are used up with 7 to 12·5-inch, except 10·4-inch and 9 and 10-inch high-angle fire guns. *Case Shot* are used in the land service with all R.M.L. guns and howitzers, except the 9 and 10-inch high-angle fire guns. *Pointed* common shell, with 8 to 12·5-inch R.M.L. guns. They are studless and of cast steel, made with a point and have a base fuze hole. *Common Shell, studded* and of cast iron, were made and are used up with 7-pr. to 12·5-inch guns, except 10·4-inch, 9 and 10-inch high-angle fire guns, 80-pr. (80-cwt.), 15-pr., 13-pr. and 2·5-inch guns. *Common Shell, studless,* of iron or cast steel, are used with 9 to 17·72-inch R.M.L. guns, except 10-inch high-angle fire guns, and also with 80-pr., 6·6-in., 15-pr., 13-pr. and 2·5-inch guns, and with all R.M.L. howitzers. *Common Shell, filled with lyddite,* of forged steel, is used with 10-inch high-angle fire guns. *Shrapnel Shell, studded* and of iron, are used up with 7-pr. to 12·5-inch guns, except 10·4-inch, 9 and 10-inch high-angle fire guns, 6·6-inch, 80-pr. (80 cwt.), 15-pr., 13-pr. and 2·5-inch guns. *Shrapnel Shell, studless,* of cast iron or cast steel, are used with 9 to 17·72-inch R.M.L., except 10-inch high-angle fire guns, and also with 6·6-inch, 80-pr. (80 cwt.), 15-pr., 13-pr. and 2 5-inch R.M.L. guns, and with all R.M.L. howitzers. *Double Shell* are used with 7-pr. and 7-inch R.M.L. guns. *Star Shell* are used with 2·5-inch guns and all R.M.L. howitzers. *Ring Shell,* with 2·5-inch R.M.L. guns.
7-pr. (150 lbs.) ..	III.	⅜ × ⅜ × ⅜ or	..	..	7¼	
„ (200 lbs.) ..	IV.	⅜ × ⅜ × ⅜ R.F.G.				
2·5-inch	I., II.	1 9/16 R.L.G.[4] or 1½ R.L.G.[2]	..	..	7¼	
9-pr.	I. to IV.	1½ or 1⅜ R.L.G.[2]	..	..	9	
13-pr.	I., II.	3½ R.L.G.[4]	..	..	13	
16-pr.	I.	3 3/16 R.L.G.[4]	..	..	16	
25-pr.	I.	4½ R.L.G.[4]	..	..	25	
40-pr.	I., II.	6⅜ R.L.G.[4]	..	..	40	
64-pr. (converted) ..	..	8¼ R.L.G.[4]	..	..	65	
64-pr.	I. and II.	6½ R.L.G.[4]	..	..	65	
„	III.	10 R.L.G.[4]	..	..	65	
80-pr. (converted) ..	I.	12 P.	..	..	90	
80-pr. (80 cwt.) ..	I.	20 P.	..	..	90	
6·6-inch	I.	25 P.	..	..	100	
7-inch (90 cwt.) ..	I.	22 P.	..	..	115	
„ (6½ tons) ..	I. to III.	30 P.	..	..	115	
„ (7 tons)	I. to IV.	30 P.	..	..	115	
8-inch	I. to III.	35 P.	..	..	180	
9-inch	I. to V.	50 P.	7½	13 4	256	
„	VI.	50 P.	..	..	256 and 360	
10-inch	I., II.	70 P.	10	20 6	410	
„	III.	..	..	..	..	
10·4-inch	I.	190 Prism[1] black	..	..	462	
11-inch	I., II.	85 P.	10	25 4	548	
12-inch (25 tons) ..	I., II.	85 P.	10	22 4	614	
„ (35 tons) ..	I.	110 P.	..	..	714	
12·5-inch	I.	165 Prism[1] black or Prism[2]	10	24 0	818	
„	II.	200 E.X.E.	10	29 8	818	
16-inch	I.	450 Prism[1] brown	..	..	1700	
17·72-inch	I.	450 Prism[1] black or Prism[2]	..	..	2000	
Howitzers:						
4-inch	I.	1¼ R.F.G.[2]	..	..	20	
6·3-inch	I.	4½ R.L.G.[4]	..	..	70	
6·6-inch	I., II.	5 R.L.G.[2]	..	..	100	
8-inch (46 cwt.) ..	I.	10 R.L.G.[2]	..	..	180	
„ (70 cwt.) ..	I., II.	11½ R.L.G.[2]	..	..	180	
R.B.L. Guns:						
9-pr.	..	1⅛ R.L.G.[2]	..	..	8½	
12-pr.	..	1⅝ R.L.G.[2]	..	..	11¼	
20-pr.	..	2½ R.L.G.[2]	..	..	22	
40-pr.	..	5 R.L.G.[2]	..	..	40	
7-inch	72 cwt.	10 R.L.G.[2]	..	..	100	
„	82 „	11 R.L.G.[2]	..	..	100	

R.B.L. Guns.

Common and segment shell, of iron and lead-coated, are used with 9-pr. to 7-inch R.B.L. guns, and shrapnel shell with 9 and 12 and 40-pr. guns.

cartridges are stored in *cases, powder, metal-lined.* The dimensions of a whole case are 17 inches × 17 inches × 20½ inches.

Powder barrels may be used for storing reserve cartridges of smaller natures of B.L. and R.M.L. for naval service when necessary.

Cylinders, Cartridge, made of zinc are used for storing, &c. all 7 to 17·72-inch R.M.L. cartridges, and also for 6-inch B.L. cartridges and upwards for land service; for 16 and 17·72-inch cartridges, the cylinders are of brass. In the latest pattern the handles are on the sides of the cases, the lids being screwed and unscrewed by a wood lever acting on two lugs in the lid. Circular packing pieces are placed at the bottom of each cylinder to prevent contact of the zinc with the cartridge, which has been found to rot the silk cloth.

Leather cartridge cases for guns under 7-inch, except field and some siege, are used for bringing up the cartridges from the magazine to the gun.

For naval service, filled cartridges are stored in *cases, powder*, rectangular, pentagonal, or cylindrical; or in zinc cylinders. There are a variety of patterns known by distinguishing letters, A to Z, some of them suitable only for particular ships.

It is absolutely essential that the lids of all cases or cylinders should be properly secured and made air-tight by luting, &c., in the manner prescribed in Mag. Reg., otherwise the strength of the powder must suffer.

Gun Ammunition Barrels are occasionally met with; they are used for cartridges, and have a circular opening in the lid.

Budge Barrels were used for holding loose powder for mortars. One of the heads was replaced by a leather bag.

Storage of Cordite.

For the transport and storage of cordite, strong deal boxes, containing 70 or 100 lbs., are used, painted stone colour. In the case of size 3¾ cordite on drums a special barrel is used. Cordite should not be stored in magazines the temperature of which exceeds 100 degrees. Instructions for the inspection and heat of test of cordite are issued in the Magazine Regulations. Cordite cartridges are stored in metal-lined cases, or zinc or brass cases, as for powder cartridges.

CHAPTER VIII.

*PROJECTILES, R.M.L., R.B.L. AND S.B. ORDNANCE.**

PROJECTILES FOR R.M.L. ORDNANCE. (TABLE VI.)

General Description.—Projectiles for R.M.L. ordnance are cylindro-ogival in shape; the bodies being cylindrical, the heads ogival. The projectiles for each nature of gun are brought about up to the same weight; they vary therefore in length. A length of between 2 and 4 calibres is necessary for accurate shooting, but a long projectile requires a higher velocity of rotation to keep it steady in flight than a shorter one.

Up to the 40-pr., projectiles for R.M.L. guns have no extractor holes; 64-pr. shells have three, and those for higher natures two.

Natures.—The various natures of R.M.L. projectiles are:—

Armour-piercing projectiles.	Case shot.
Common shell, including double shell.	Star shell.
	Ring shell.
Shrapnel shell.	

Armour-Piercing Projectiles.—Those in the Service consist of forged steel shot and Palliser shot. Palliser are used with 80-pr. R.M.L. guns and upwards, and are made of a special white cast iron.

Palliser Shot.—In order to ensure density and soundness in the head, these are cast point down; the heads being cast in an iron chill or mould, the bodies in sand, by which means, owing to the conductivity of the metal mould, the molten mass rapidly cools, and gives great hardness and crushing strength but considerable brittleness to the head of a Palliser projectile.

The bodies being cast in a sand mould, acquire by that means more tenacity but less hardness than the head.

The fracture of a Palliser shot shows the metal of the head to be white, whilst that of the body has a mottled appearance, though both were cast out of the same ladle.

* The numerical value of the expression $\frac{\text{weight of shot}}{(\text{diameter})^3}$ or $\frac{w}{d^3}$ gives the relation between weight and calibre: and is ·3 to ·4 for R.M.L. projectiles.

The ogival head was struck with a radius of $1\frac{1}{2}$ diameters, but two diameters are now used.

These projectiles are nearly equal to steel shot as regards penetration of wrought iron; but they do not possess sufficient tenacity to enable them to be effectively employed against compound or steel-faced armour.

Stud holes are a source of weakness in projectiles, and consequently studded shot are inferior as regards penetration to those without studs.

Palliser shot are tested in manufacture by a water pressure of 100 lbs. on the square inch, and also by a hammer test on their bases to detect any weak or porous portion; they were formerly lacquered internally with red lacquer, and a bursting charge of shell powder contained in a serge bag was used which completely filled the projectile, no fuze being required.

The hole in the centre of the base is bushed with cast iron, the bush being cast in the shell; in it is cut the screw-thread into which the gun-metal plug screws, the iron of the shell being too hard to admit of tool work.

The use of bursting charges with Palliser projectiles was discontinued, but Palliser shell for naval service have been again introduced for 9, 10, 11 and 16-inch.

Palliser shot, which were formerly shell, are weighted with sand, and marked with the letter W on the head and base plug. For protecting the points of Palliser projectiles, see B.L. shell.

Armour-piercing shot are described under B.L. projectiles.

Common Shell.—Common shell are made for all natures of ordnance, being used for the destruction of material, and as a projectile against troops behind cover; and they are effective for the attack of the lighter armour of vessels.

They are of cast iron or of cast or forged steel; the thickness of the walls being from $\frac{1}{5}$th to $\frac{1}{8}$th of the diameter in the case of cast iron. It is desirable that they should contain as large a bursting charge as possible, and at the same time be strong enough to resist the shock of discharge, or impact against material, hence steel are now superseding cast-iron shell.

These shell are lacquered inside, the bursting charge being contained in a serge bag in the case of 64-pr. shells and upwards; and for the 16-pr. R.M.L. In cast-steel shell the burster bag is of silk cloth, and in certain cases of dowlas. Shell L.G. powder is used for R.B.L. guns and iron shell for practice, but bursting charges otherwise consist of pebble and fine-grain powders; except that shell Q.F. and F.G. are used for 12-pr. B.L. and Q.F., and may be used up to 6-inch except 3 and 6-pr. Certain common shell are filled with lyddite.

Percussion fuzes are used as a rule with common shell.

All common shell, down to 40-pr. inclusive, are bushed with gun-metal, the bush being of G.S. fuze hole gauge.

The G.S. wad is placed in all common shell when the bursting charge is not contained in a bag.

Primers consisting of 7 drams of F.G. powder in a red shalloon bag are used when the bursting charge is contained in a bag. With shell filled at the base three are used; when filled at the nose one or more, according to room available after filling. The 17·72-inch shell takes 10-oz. primers. Cast-steel common shell pointed, taking the fuze percussion base large, are issued for sea service for 8 to 12·5-inch guns.

Double Shell.—Double shell are used with 7-pr. and 7-inch R.M.L. guns only; in construction they resemble common shell, but are longer, that for the 7-inch being 4 calibres; at long ranges their shooting is not good.

Shrapnel Shell.—Shrapnel shell are used with all natures of rifled ordnance. The body is of cast iron or steel, having the walls and base of nearly the same thickness as common shell for the same gun. In the case of 7-inch cast-iron shrapnel and upwards six grooves, forming lines of least resistance, are cast in the interior and in the base to facilitate the shell breaking up, but 64-pr. and 80-pr. shrapnel have grooves in the base only, and natures below have no grooves. Steel shrapnel have no weakening grooves.

At the base the shell contracts and forms a chamber for the bursting charge, which is contained in a tin cup fitting into the chamber. A wrought-iron or steel disc is placed over the coned top of the tin cup; and a wrought-iron pipe, which is screwed into a central hole in the disc, extends up through the centre of the shell. The pipe is slightly recessed at the top for a gun-metal socket, the lower portion of which is tapped to receive a screw primer, the upper portion being of the G.S. pitch and taper.

Round the central tube are placed the balls, which are iron sand shot 4 oz. in weight for calibres above 9-inch, 2 oz. for 7-inch, 8-inch, 9-inch, and mixed metal (4 lead, 1 antimony), 14 to the lb., for 80 and 64-prs.* Molten rosin is poured on the balls to fix them, a brown paper lining being inserted to prevent the rosin adhering to the shell, and a felt ring placed on the top of the balls. The head of the shell is of Bessemer metal struck with a radius of one diameter; it is lined with wood, and is lightly attached to the body by rivets and twisting pins, covered with a band of solder.

In the case of shrapnel of 40-pr. and lower natures, the central

* 34 to the lb. for field and mountain shrapnel.

tube is of gun-metal, in the top of which is screwed the metal primer. A tin socket is soldered over the top of the tube, into the upper portion of which the gun-metal socket fits; with 64-pr. and 80-pr. shrapnel a thin wooden tube is placed round the central iron tube.

The object of a *primer* in shrapnel shell is to convey the flash from the fuze to the bursting charge at the base, and also to prevent any powder working up into the fuze socket; the body is of gun-metal filled with loose powder; the top has a cup-shaped recess containing three small holes, and the bottom is closed with a thin brass disc. Mark III. primer, which is the latest pattern used, has the top made larger in diameter, forming a shoulder, under which a leather washer soaked in ozokerine is placed.

The bursting charge of shrapnel consists of quick-burning powder, in quantity just sufficient to open the shell; time fuzes are generally used, percussion shrapnel being exceptional.

This shell is essentially for use against personnel, its effect on material being very small. The higher the velocity of the shell at the time of bursting, and the less its angle of descent, the greater will be its effect; and at long ranges, the shell having a low velocity and a higher angle of descent, the shell must be burst much closer to the object than at short ranges. The cone of dispersion of the bullets is from 7° to 12°, and shrapnel from medium and heavy guns may be burst 400 or 500 yards in front at short ranges, with a proportionate decrease as the range increases.

The effect of shrapnel depends to a great extent on the results of the fire being correctly estimated; and it is often possible to see the bullets grazing.

R.M.L. 15-pr. and 2·5-inch Shrapnel.—The shrapnel for these guns has a steel body, the head of malleable cast iron is screwed on, the base of the same metal being riveted. The bursting charge of L.G. powder in a bag is contained in the head; and the tube down the centre and wooden head being dispensed with, there is greater capacity for the bullets.*

Case Shot for R.M.L. Guns.—These projectiles should not set up on discharge and take the rifling, but they must release their contents easily on leaving the bore, and at the same time be strong enough for transport.

In 7-inch and under, with a few exceptions, a case shot has the body made of tinned iron in three pieces, soldered longitudinally together; the bottom, soldered to the body, has an iron

* The explosion of the bursting charge causes the head and body to be drawn over the bullets without breaking up, the bullets leaving at the base end.

ring riveted on outside; the top end is fringed and bent down over a tinned iron top and soldered.

Above 7-inch the body is made of one piece fringed at both ends, the bottom being an iron disc, and the top as for lower natures. Up to 8-inch a case shot has one handle, above 8-inch two handles, which are placed away from the charge.

All case shot contain three loose wrought-iron segments forming a lining, 64-pr. and 80-pr. case have six.

Up to 40-pr. the contents are mixed metal balls, and for higher natures 8-oz. sand shot; the balls being packed in clay and sand. In special cases chilled iron shot are issued for 9 to 12·5-inch guns for use with cordite charges.*

All recent patterns of case shot are of about the same weight as other projectiles; when otherwise two case shot would as a rule be used. Case shot are effective up to 800 or 900 yards from heavy guns, and 300 to 400 yards from lighter natures; their effect is greatly increased on hard ground, which causes the bullets to ricochet.

In case shot for 12·5-inch, 16-inch, and 17·72-inch guns a wrought-iron stay bolt passes longitudinally down the centre, being secured at either end.

Star Shell.—Star shell are used with the R.M.L. 15-pr. and 2·5-inch, and with B.L. howitzers, and consist of a thin steel shell with a cast-iron base. The interior contains paper cylinders filled with magnesium light composition, which give a brilliant light and burn for about 40 seconds. The top of the shell is of wood covered with tin, and contains a fuze socket, a tube serving to convey the flash of the fuse to the burster in the base.

Spherical star shell are used with R.M.L. howitzers; the hemispheres of which they are composed are of Bessemer metal, and are filled with stars of magnesium light composition.

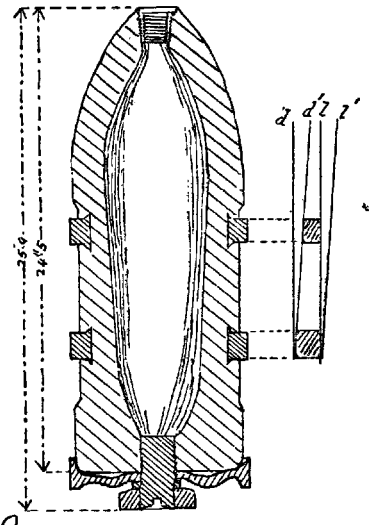
Ring Shell are issued for 2·5 inch guns. The shell is of cast iron on a core of iron rings, which are weakened so as to break up each into 6 segments. Incendiary stars can be placed in common or ring shell when required.

Studded Projectiles for R.M.L. Ordnance.

Description.—Projectiles for R.M.L. ordnance, with the exception of case shot, were formerly provided with studs for giving rotation, which were pressed into under-cut holes, cast in Palliser projectiles, and cut in other natures of shell; the studs were made usually of an alloy of copper and tin.

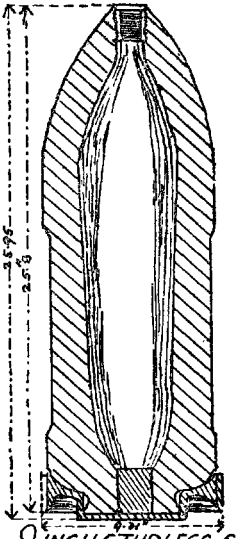
* For the defence of mine fields.

FIG. 1. SCALE 1/10.5



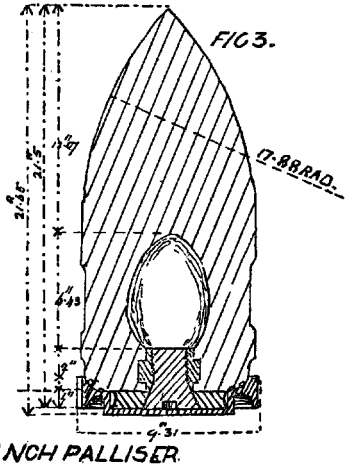
9 INCH COMMON SHELL
& GAS CHECK (II)

FIG 2.



9 INCH STUDLESS C. SHELL
& ROTATING GAS CHECK.

FIG 3.



9 INCH PALLISER
STUDLESS SHELL,

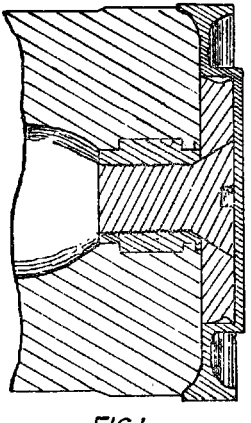


FIG. 4.

BASE OF ALTERED STUDDED SHELL.

Studded projectiles, though not now made for 8-inch guns and upwards, still exist, except for polygrooved guns.

The rear studs of 7-inch projectiles and above are 1·42 inch in width, the grooves in these guns being 1·5 inch wide; the width of the front stud is limited by the amount of twist of rifling at the muzzle: with a uniform twist the front studs are similar to the rear ones, but with an increasing spiral the front stud must be reduced to remain opposite the groove in all positions; its breadth must allow the shell to pass down the bore, and must not therefore extend beyond *l*, see Fig.; nor beyond *d'* when being rammed home. A small portion only of the work of rotation falls upon the front studs, their chief use being to steady the projectile in the bore.

The height of the studs above the shell is greater than the depth of the groove in the gun, this difference, termed "clearance," amounts to 0·015-inch.

The body of the shell is never therefore in contact with the bore, and both direction and twist are given by the studs.

There is windage over the projectile as well as over the studs, and the projectile with this system of rifling is never properly centered.

The edges of studs are circular, being struck with a radius of from 0·3 inch to 0·25 inch, according to the nature of gun, and they are planed so as to fit the grooves.

There are two rings of studs on each projectile, except the 12-inch of 35 tons and 12·5-inch (I.), which have three; and the number in each ring corresponds to the grooves in the gun.

64-pr. projectiles have three rings of copper studs, three in each ring; their form is cylindrical with the sides slightly bevelled off. 80-pr. projectiles have copper and zinc studs; the front studs are made smaller than the rear ones, although the gun has a uniform twist of rifling; this is in order to diminish the strain on the shell when forcing the studs into it. The common shell has a strengthening belt running round inside under the front stud.

Studs weaken a shell and do not admit of its being properly centered, i.e. the axis of the shell does not quite coincide with the axis of the piece; further, the deep grooves in the gun, which are few in number, weaken it, and the strain is not evenly distributed over the bore; there is also a loss of some of the force of the powder gas owing to windage; the latter defect, however, is remedied by the use of gas-checks.

Service Gas-Check for Studded Projectiles.—The Service gas-check was introduced for use with studded projectiles for certain guns, to stop the rush of powder gas that occurred over the top of the projectile especially; this eroded the bore to such an

extent as to render a heavy gun unserviceable after firing a limited number of rounds.

Mark II. Service gas-check, in use for studded projectiles of 9-inch and upwards, consists of a disc of copper and zinc, with a central hole; it is painted black on the outside; the face, which is placed against the base of the projectile, being concave and unpainted. Projections on its edge fit the grooves in the gun; and it is attached to the base of the shell by a plug and nut, the plug having a shoulder to prevent the nut binding on the gas-check; the latter can thus revolve freely on the plug for convenience in loading.

By the use of this gas-check not only is erosion almost completely checked, but there is an increase in muzzle velocity owing to there being no loss of pressure of powder gas; also the projectile is more nearly centered, hence greater accuracy is obtained.

Studless Projectiles and Automatic Gas-checks for R.M.L. Ordnance.

Description.—Studless projectiles are used with all R.M.L. polygrooved guns, and also with 80-pr. to 12·5-inch R.M.L. guns rifled on the Woolwich system,* the stock of studded projectiles for the latter guns being, however, used up.

These projectiles are cast with a projecting base, having a neck or groove for the attachment of a gas-check for giving rotation. The curved portion of the base of the shell is cast with radial serrations and one circumferential groove, into which the inner surface of the gas-check is compressed on discharge; at the same time the gas-check is forced into the groove or neck round the projecting part of the base, and becomes firmly attached to the shell (Plate IX. Fig. 2).

The Gas-Check, Copper, Automatic, has projections on its circumference corresponding with the grooves of the gun; it is inserted loose in the bore, in the proper direction, and fits itself on the base in ramming home.

The bodies of the shell are cast to finished dimensions, with a windage of 0·2 inch; bands being left at the base and head 1·5 inch wide, which are turned or ground down to a windage of 0·06 inch.

Studless common shell are filled from the base end, suitable burster bags being used, made of serge, silk cloth, or dowlas (6381).

Filling Studless Shell.—Shell-holders of wrought iron, one-

* Except 7-inch guns.

half working freely on a joint which can be tightened up by means of a spanner attached to the holder, are used with shells filled from the base end; a large or small brass filling rod being employed to fill the shell.

Studless Palliser Shot, Mark II., *9-inch to 12·5-inch.*—The latest pattern of studless Palliser shot for R.M.L. guns from 80-pr. to 12·5-inch (Mark II.) differ from the ordinary pattern in having their bases fitted with wrought-iron discs for the reception of the cupped part of the gas-check, instead of the projecting part of the base forming part of the iron of the shell itself.

This pattern was made in consequence of its being found that the iron of the base end was liable to be injured in transit.

In certain cases rope grummets are issued with studless projectiles, being placed over the projecting base for protection; they must be removed before loading.

Projectiles for 17·72-inch, 16-inch, and 12·5-inch (II.).—Studless shell for 16-inch and 12·5-inch guns have in rear of their centre of gravity a hole for the reception of a pawl on the trolley used for bringing the shell up to the gun, and on their opposite side a screwed hole is cut for an eyebolt, for use with a lifting tackle. Projectiles for the 17·72-inch gun have an eyebolt hole only.

Projectiles for Armstrong R.B.L. Guns. (Table VI.)

Natures.—The projectiles used with these guns are segment shell, common shell, shrapnel shell and case shot. Solid shot have been made, but are used for practice only.

Segment Shell.—Segment shell, are projectiles peculiar to this class of guns. The shell consists of a thin cast-iron cylindro-conoidal body, lined with cast-iron segments, built up in layers, leaving a cylindrical chamber in the centre; the base is closed with a disc of cast iron.

The shell is strong to stand the shock of discharge, but a small bursting charge will open it.

An outside coat of an alloy of 19 parts of lead to one of antimony extends from base to shoulder; the alloy also flows in between the segments and lines the powder chamber; a recess in the base of the iron disc also fills with alloy, the disc being thus kept in its place. A cannelure on the outside of the shell receives any lead stripping off the front part.

The shell is first dipped in a zinc bath, and on applying the lead coating it becomes chemically attached to the iron of the shell.

Segment shell are very effective against troops in column, and should be burst close up to them, as the shape of the segments localises their effect after the shell is opened. They have also given good results against troops behind a thin wall, and would be effective against boats, &c., a percussion fuze being employed.

Common and Shrapnel Shell.—The common and shrapnel shell are similar in construction to those for R.M.L. guns, with the exception of the lead coating for imparting rotation.

The bursting charge of 40-pr. common shell is contained in a serge bag, in consequence of premature bursts having occurred.

Shrapnel shell, though existing for 40-pr. and 7-inch R.B.L. guns, do not form part of their equipment.

Case Shot.—Case shot for these guns have studs of solder at their rear ends to prevent their being over-rammed; in other respects they are similar to R.M.L. case shot. The case for 7-inch R.B.L. is suitable for the 7-inch R.M.L. gun.

Projectiles for Smooth-Bore Ordnance.

Natures.—These consist of—(i.) Shot, viz. solid, case, grape, and sand; (ii.) Shell, viz. common, naval, mortar, hand grenade, diaphragm shrapnel.

Shot.—Solid shot were made for all calibres of guns except 8-inch and 10-inch shell guns, and were of cast iron.

Case were made for all S.B. ordnance, except mortars.

Grape shot consist of sand shot held in position by four circular iron plates, pierced with holes to grip the shot; an iron spindle passes through the plates, and a nut at the head of the spindle binds all together: they were superseded by case.

Sand shot are cast-iron balls varying in weight from 4 lbs. to 1½ oz., and are now used for filling shrapnel and case.

Shell.—Common shell were used with all S.B. ordnance; they have the common fuze-hole gauge, and are fitted with wooden bottoms attached by a gun-metal rivet; the fuze hole is tapped throughout to take Pettman's L.S. fuze, and marked with a +.*

Naval Shell have the general Service gauge, and the wood bottoms are fixed by two rivets.

Mortar Shell have the mortar gauge, which is larger than the common; they have no wood bottoms, and are used with 8-inch, 10-inch and 13-inch mortars.

Hand-Grenade Shell are of two sizes, 3 and 6-pr.; they are used

* A papier-mâché wad is placed in the fuze hole of filled common S.B. shell. Filled S.B. shell are marked with a red band 1½ inch from the edge of the fuze hole (5336).

with a special fuze, and can be thrown by hand; they were used in the defence of places against assault, by grenadier companies.

Diaphragm Shrapnel have the common gauge, and were fired from all S.B. ordnance except mortars. The shell is made of thin cast iron, weakened by four grooves down the side. A wrought-iron cup or diaphragm divides the shell into two unequal parts; the smaller and upper portion containing the bursting charge, the larger one the bullets, which are of lead and antimony.

Carcasses are incendiary shells, and were fired from all S.B. ordnance; before firing, the plugs and plaster over the three vents were removed; they burnt from 3 to 12 minutes, and were unextinguishable in water.

Ground Light Balls were fired from mortars for the purpose of lighting up an enemy's works; they consist of a skeleton iron frame covered with canvas and filled with composition; the vents were uncovered before firing.

Parachute Light Balls were fired from mortars for lighting up an enemy's works; they float in the air whilst burning from 1 to 3 minutes, but are easily affected by the wind.

TABLE VII.—CHARGES OF S.B. ORDNANCE.

S.B. GUNS.	Charge. lbs. oz.	S.B. GUNS—*continued.*	Charge. lbs. oz.
18-pr. 42 cwt...	6 0	68-pr. 95 cwt.	16 0
24 „ 50 „	8 0	68 „ 112 „	18 0
32 „ 50 „	8 0		Full.
32 „ 58 „	10 0	MORTARS.	
42 „ 84 „	14 0	13-in. 100 cwt.	20 0
8-in. 65 „	10 0	13 „ 36 „	9 0
10 „ 86 „	12 0	10 „ 18 „	4 0
		8 „ 9 „	2 0

Weights of Mortar Shell.—The 13-inch mortars of 36 and 100 cwt. fired a shell weighing 195 lbs. with a bursting charge of 10 lbs. 15 oz.

The 10-inch mortar of 18 cwt., a shell of 87 lbs. with a bursting charge of 5 lbs. 4 oz.

The 8-inch mortar of 9 cwt., a shell of 46 lbs. with a bursting charge of 2 lbs. 9 oz.

CHAPTER IX.

PROJECTILES FOR B.L. GUNS.

See TABLE V.

THE natures of projectiles used with B.L. guns are armour-piercing projectiles, common shell, shrapnel shell and case shot.*

Armour-piercing Projectiles.—Armour-piercing shot are made of both forged and cast steel, their bases being closed with a screwed-in plug; in general appearance they are similar to Palliser shot, which they have replaced; the latter, however, are still in the service for certain guns.

The steel shot are brought up to the service weight of other projectiles by filling with dust-shot and sawdust. The heads of the shot are struck with a radius of two diameters, and their lengths are from $2\frac{1}{2}$ to 3 calibres; bands are left round the shoulder and portion of body in front of the driving band, and these are ground down to allow of a windage of ·05 inch; over the remaining portion of the body of the shell there is a windage of 0·15 inch. Jute protecting bags are used for preserving the points of armour-piercing projectiles in transport. Palliser shell containing a small bursting charge are also used for naval service with 4 to 16·25-inch B.L. guns; these shell taking the base percussion fuze No. 11.

Common Shell.—B.L. common shell are of iron, forged and cast steel, the metal used being stamped on the base and included in their nomenclature. The following is an example of the service designation of a projectile: "Shell B.L. (filled or empty) common, 13·5-inch, cast steel, Mark I." Iron common shell are filled from their base ends, excepting 12-pr., 4 and 5-inch natures, which have solid bases. A different pattern of bag is required for a shell filled at the base to that used when filled at the nose. The hole in the base is made for manufacturing reasons, and is used for filling for convenience. In 6-inch iron common shell and upwards the base plugs are countersunk, lead discs made in two sizes being hammered in after the shells are filled. In cast-iron shell the

* The value of $\frac{w}{d^3}$ (see p. 68) is ·4 to ·5 for B.L. projectiles, showing that the latter are longer than those for R.M.L. guns.

walls are for strength made thicker than those of steel shell, and their capacity for a bursting charge is therefore lessened.

Cast Steel Common Shell.—In these shell the filling hole at the base end is closed by a gun-metal adapter and plug of the same pattern for all natures. Pointed common shell are also used with B.L. guns (8105), being intended to carry their bursting charge through armour; they take base percussion fuze No. 11.

Forged Steel Common Shell.—The walls of these shells can be made thinner than when cast iron or steel is used, and there is less risk of their breaking up in the bore. Forged steel is therefore preferable for common shell when a violent explosive is used as a burster, as in the case of lyddite shells in the service. At the same time a forged steel shell does not break up into as many fragments on burst as cast steel or iron, and for that reason would be less destructive in certain cases. Forged steel shell usually have solid bases, except in the larger natures, where for manufacturing reasons a base hole is also used.

Bursting Charges of Common Shell.—The bursting charge of powder-filled shell consists of a mixture of P. and F.G. powder, but Q.F. and F.G. powders are used for 12-pr., and may be used up to 6-inch, except 3 and 6-pr. shell. Burster bags are used to contain the charge, made of silk-cloth or dowlas, and shalloon primers of F.G. powder are placed between the fuze hole and bursting charge. For sea service a red "wad naval with loop" is cemented into the recess of the fuze hole to keep out moisture, and if the shell are also fuzed they are stencilled accordingly.

In the case of high explosive shells lyddite is used for the bursting charge; a picric powder exploder being inserted in a recess left in the lyddite for that purpose. Lyddite shell are of forged steel, and take a noze fuze. Their destructive effect on burst is much greater than that with powder-filled shell, and is due to the excessive blast produced by the very violent and rapid explosion or detonation of the lyddite.

Shrapnel Shell.—These shell are made of iron and forged or cast steel, and are in construction generally similar to R.M.L. shrapnel, except that 80-pr. and 4-inch shrapnel have a bursting charge of L.G. powder in the head; this arrangement gives more capacity for bullets, but the striking velocity of the latter is retarded. In the case of iron or cast-steel shrapnel the bodies break up on burst, but with forged steel, which are now in general use, the body goes on whole after burst, after forming a tube which tends to increase the striking velocity of the balls.*

Case Shot.—These projectiles are similar generally to those in

* In the case of 12 and 15-pr. shrapnel the bullets are contained in a perforated tin cage or a wire cage, to give greater striking effect.

use with R.M.L. guns, they are not, however, issued for B.L. guns for sea service.

Driving Bands.

Vavasseur Driving Band.—This band is attached near the base end of all B.L. projectiles except case shot, for the purpose of giving rotation. The diameter of the band is slightly larger than that of the bore over the lands, and on discharge is cut into or engraved by the latter, whilst at the same time it is compressed into the grooves of the gun. For attachment to the projectile a groove is turned or cast in the latter sufficiently far back to be consistent with there being metal enough behind the band for its support. In the groove projecting ribs of triangular section are left, which are not, however, continuous round the circumference; the band is pressed into the groove, the ribs preventing any tendency to slip.

The band itself, which is cut from drawn copper annealed tubing, is cylindrical, with a front slope of 7 degrees, its width, including half the slope, being one-fourth of the calibre, and its diameter exceeding that of the bore across the lands by ·0023 of the calibre. Cannelures are cut on the outer circumference rectangular in section, and undercut at the bottom for the attachment of augmenting strips when used; there are two cannelures in bands up to 6-inch, three to 9-inch, four to 12-inch, and five to 16·25-inch shell; they serve to prevent the metal stripping and forming a projecting fringe that would cause unsteadiness in the flight of the shell. The front slope of the band for 9·2-inch shell and above is corrugated, causing it to grip into the cone between the charge chamber and bore when loading, this being especially necessary at high angles of elevation. With B.L. guns firing cordite charges a "*Vavasseur driving band with gas-check*" is used (8422); in this band a projecting ring of copper serves to seal the gas and lessen erosion and wear of the gun.

The original pattern of driving band used was a narrow band without cannelures, which is still met with in the older projectiles.

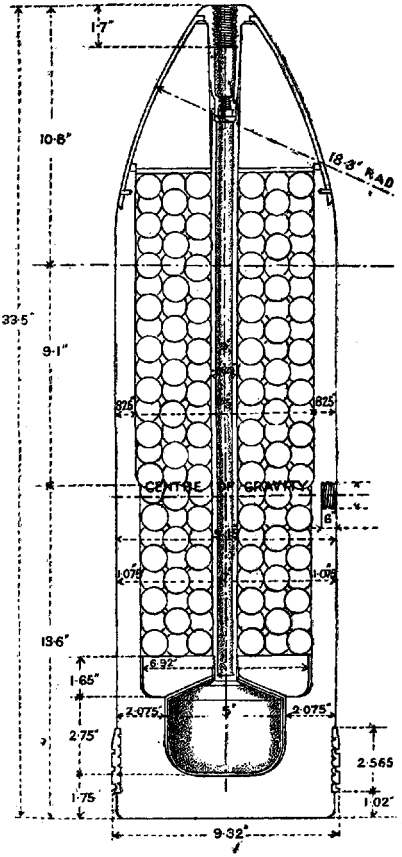
Augmenting Strips.—These are used when B.L. guns owing to wear fail to properly rotate their projectiles. The strips of copper are hammered into one or more of the cannelures of the band as required, the undercut serving to retain them in position.

8-inch Shell and Upwards.

A small hole with a screw thread cut in it is made in the body of 8-inch projectiles and upwards, in line with the centre of gravity,

PROJECTILES. B.L. 9·2 INCH.

SCALE $\frac{1}{6}$



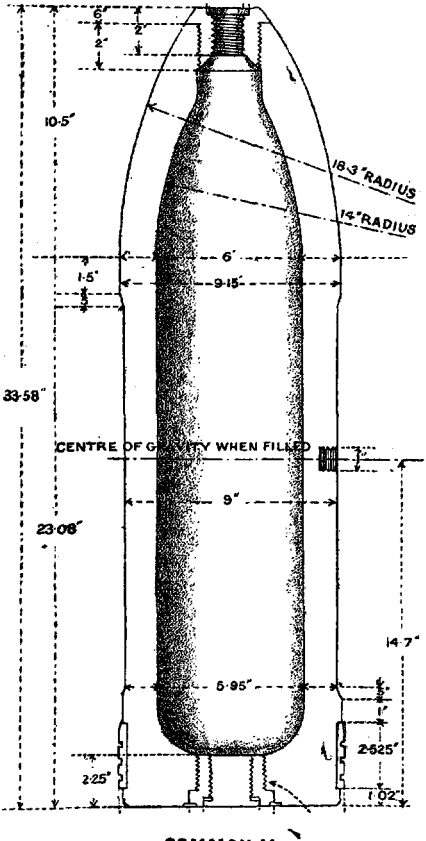
SHRAPNEL III

FORGED STEEL.

AVERAGE TOTAL WEIGHT=LB. 8 OZ. 0

900 SAND SHOT(2 OZ.)= 112.8

BURSTING CHARGE = 1.8



COMMON V.

CAST STEEL

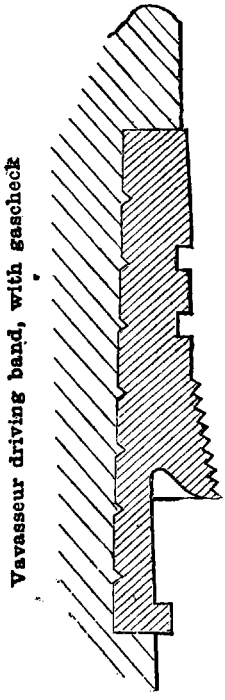
AVERAGE TOTAL WEIGHT=LB. 8 OZ. 0

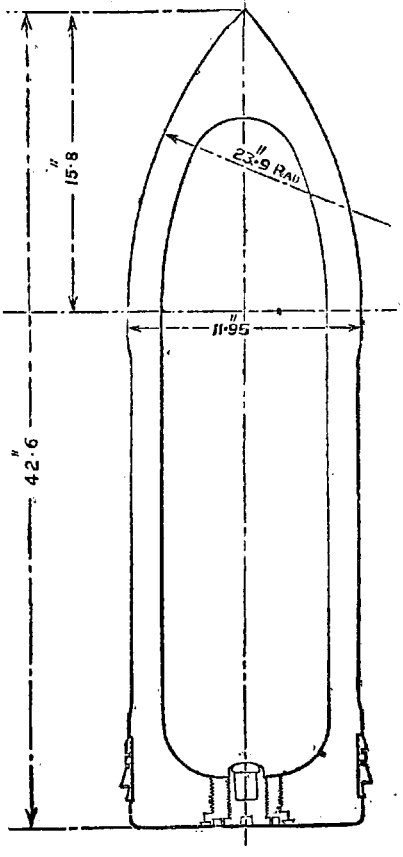
BURSTING CHARGE = 30.6

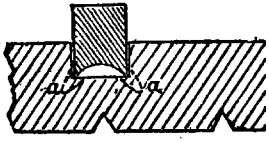
P. AND F.G

Shell, B.L., common, pointed, 12-inch, Mark I.

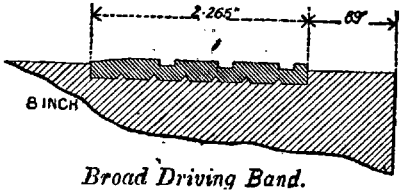
Scale $\frac{1}{10}$.







Augmenting strip



Broad Driving Band.

for the reception of an eye-bolt for a lifting tackle. In the case of armour-piercing projectiles a sling of 4-inch spring steel is used round the shell for lifting purposes.

Distinguishing Marks on Projectiles for all Ordnance.

The following marks are painted on projectiles, in order that they may be readily identified, in addition to the markings stamped on their bases:—

Shot, except case shot,	have white tips.
Common and Palliser shell	„ black „
Segment and ring shell	„ blue „
Shrapnel shell	„ red „
Steel projectiles	„ one white band.
Armour-piercing projectiles	„ two white bands.
Practice projectiles	„ one yellow band.
Filled shell	„ one red band.
Lyddite shell	are painted yellow.
15-pr. shrapnel	„ lead colour.
All other projectiles	„ black.
Base fuzes (only) in shell	„ red.

Energy of a Projectile at the Muzzle.

Energy.—When a projectile is moving, it is capable of overcoming resistance or doing a certain amount of work; this is termed the energy of the projectile.

$$\text{Energy} = \frac{\text{weight of projectile} \times (\text{its velocity})^2}{2\ (\text{force of gravity})}$$

$$\text{or} \quad E = \frac{W V^2}{2g} \text{ foot-pounds}$$

$$= \frac{W V^2}{2g \times 2240} \text{ foot-tons.}$$

Thus the 9·2-inch B.L. gun, Mark VIII., firing a projectile of 380 lb. with a muzzle velocity of 2347 foot-seconds has a muzzle energy of

$$\frac{380 \times 2347^2}{2 \times 32{\cdot}19 \times 2240} = 14515 \text{ foot-tons.}$$

In order to compare the power of guns for piercing armour plates, the energy may be divided by the number of inches of the shot's circumference.

Thus in the case of the 9·2-inch the muzzle energy per inch of shot's circumference is

$$\frac{14515}{\pi d} = \frac{14515}{3{\cdot}1416 \times 9{\cdot}12} = 505{\cdot}7 \text{ foot-tons.}$$

It will be observed that the energy stored up in a projectile as it leaves the gun increases as the square of its velocity: thus a small increment of muzzle velocity adds considerably to the muzzle energy. Modern guns have muzzle velocities of 1800 to 2700 foot-seconds, and their muzzle energy is consequently very great in comparison with the corresponding natures of old-type R.M.L. guns, whose muzzle velocities are from 1200 to 1400 foot-seconds.

Relation between Weight and Diameter of a Projectile.—The penetration with projectiles having equal energies on impact depends on the relative value of W the weight and d the diameter of a projectile. The proportion found to give the best results is when

$$\frac{W}{d^3} = 0{\cdot}364 \text{ to } 0{\cdot}5.$$

Filling Shell R.M.L. or B.L.

Common shell are filled from the nose or base, suitable burster bags being issued. In many cases, iron, cast steel, and forged steel common shell all exist for the same nature of gun; and before filling it is therefore of great importance to ascertain the mark of the shell and its material, in order that the correct bursting charge and burster bag may be used. As already pointed out, forged steel common shell are, as a rule, filled at the nose, and cast steel from the base. With granulated powder and light shell the process of filling is simple; but with heavy shell filled with P. and F.G. mixture, and especially if from the nose, the operation is a tedious one to ensure the proper weight of powder being got into the shell. Should a shell be not carefully filled, subsequent movement will cause the powder to settle down, and, a space being left under the fuze hole, a blind shell would probably result, although primer bags 7 drams are used to remedy this.

To upend heavy shell for filling is not an easy matter, and a Gibraltar gyn in the filling room, or a triangle gyn in the open,

have had to be made use of on occasions: shell should not, however, be filled in the open, dust and foreign matter being liable to enter the shell.

Shell should not be rolled or moved about on the bare floor of a laboratory, but wadmil tilts should be freely used, and barrels containing powder in use should be kept well clear of the upended shell; these precautions being specially necessary in the case of 12-inch shell and upwards, R.M.L. or B.L. When shell are filled they should be properly marked at the time to avoid any subsequent mistakes.

Emptying shell requires careful supervision, many accidents having occurred at this work. In dealing with dirty and dusty powder, such as that obtained from shell and from old cartridges when broken up, additional caution is necessary; the atmosphere of the room becomes impregnated with finely divided particles of powder, which permeates everywhere; the floor should be wetted in these cases.

In filling shrapnel shell the chief points are to ascertain that the cups at the bottom of the shell are not only dry but also bright and free from rust; if otherwise, the shell should not be filled but condemned for practice. The bursting charge of shrapnel must be very correctly weighed out, and the primer screwed in after being lubricated.

CHAPTER X.

FUZES, TUBES, ETC.

Fuzes for Rifled Ordnance. Wood Time Fuzes.

Description.—Time fuzes of beech wood are made conical in shape, to ensure their fitting the fuze socket, which in all rifled shell is of the G.S. gauge and taper: a G.S. plug is screwed into shell that are not fuzed, and a "plug special fuze hole" is used for projectiles filled with lyddite and taking nose fuzes (8631).

The following are the *wood* time fuzes in the Service for rifled ordnance :—

Table VIII.—Time Fuzes. (Wood).

Name of Fuze.	Time of Burning at Rest.	No. of Powder Channels.	Graduated to	Charged with	
	secs.		secs.		
Fuze time 5 secs. M.L.	5	2	¼	Mealed powder (1″ in 2½ secs.).	Without Detonators.
„ „ 9 secs. „	10	2	½	Fuze composition (1″ in 5 secs.).	
„ „ 15 secs. „ No. 41	15	6	¼	Fuze composition (1″ in 7½ secs.).	
„ „ 20 secs. „	20	Nil	Seconds	Fuze composition (1″ in 5 secs.).	
„ „ 30 secs. „ No. 40	30	8	¼	Fuze composition (1″ in 10 secs.).	
Fuze time 5 secs. B.L.	5	2	¼	Mealed powder (1″ in 2½ secs.).	With Detonators.
„ „ 9 secs. „	10	2	½	Fuze composition (1″ in 5 secs.).	
„ „ 15 secs. with detonator No. 43	15	6	¼	Fuze composition (1″ in 7½ secs.).	

The above fuzes are obsolete as regards manufacture, but are used up for practice; metal time fuzes having replaced them.

The 15 seconds originally replaced the 5 and 9 seconds, and the 30 seconds the 20 seconds fuze.

The fuze composition used is pit-mealed powder, saltpetre, and sulphur, the rate of burning being regulated by the amount of pressure the pellets of the composition undergo; also an addition of pit-mealed powder accelerates the rate of burning, saltpetre and sulphur the converse.

M.I. Wood Time Fuzes.

Fuze, time, 15 seconds M.L. No. 41, Mark II., is charged with 2 inches of fuze composition burning at the rate of 1 inch in $7\frac{1}{2}$ seconds; it has 6 powder channels bored parallel to the axis of the fuze, and filled with pistol powder, also side holes into which pistol powder is pressed. The fuze is graduated to $\frac{1}{4}$ seconds, the side holes being numbered 1, 1·5, 2, 2·5 . . . 30.

A groove round the head of the fuze contains quick-match priming, which also passes through two holes into the fuze, being looped round the pin of a gun-metal plug which is screwed into the head of the fuze. The priming in the groove is protected by a copper band enclosed in tape and covered with paper; this band is removed before the shell is rammed home. A paper lining between the wood and the composition prevents the formation of a space in the event of the wood shrinking, that would cause the fuze to act prematurely. The powder channels are connected at the bottom by quick match, and the last side hole is bored through into the composition.

The fuze is painted black and drab.

It is used with all R.M.L. guns, except 2·5 inch 13-pr., 40-pr., 6·6 inch, and 9 inch.

Fuze, time, 9 seconds M.L., and 5 seconds M.L., differ from the above, as shown in Table VIII. The 9 seconds is painted black and drab, and the 5 seconds red and drab.

Fuze, time, 30 seconds M.L. No. 40, is charged with 3 inches of fuze composition, burning at the rate of 1 inch in 10 seconds: and has eight powder channels to allow of space for side holes graduated to quarter seconds.

The side holes are numbered consecutively in a spiral direction, commencing at 30, 30·5 up to 60. The fuze can therefore be only used for times of flight over 15 seconds. In consequence of there being an increased number of powder channels, the lower part of the fuze from the commencement of the side holes is made cylindrical. A gimlet borer is used with this fuze. It is painted black and drab.

Fuze, time, 20 seconds M.L., is charged with 4 inches of fuze composition, burning at the rate of 1 inch in 5 seconds. It has no powder channels, and is graduated to seconds from 20, 22 . . . .

40. It can therefore only be used with common shell whose times of flight exceed 10 seconds.

Action of M.L. Time Fuzes.—In wood time fuzes without detonators, the quick-match priming is lit by the flash or blast at the muzzle and ignites the fuze composition; the latter burns down to the hole bored, when the powder channels flash off into the shell. If a fuze is not bored, it will still act at the last side hole, which is bored through into the composition. In the case of the 20 seconds fuze the flame from the composition acts at once through the side hole; this fuze would therefore fail to burst a shrapnel shell, where a downward flash is required. These fuzes are screwed into the shell (5506), as in the case of those with detonators.

Wood Time Fuzes with Detonators.

Fuze, time, 15 seconds with detonator No. 43, Mark III.—This fuze is similar to the 15 seconds M.L. fuze, except that a detonator is screwed into the head, the latter being strengthened by a woolding of copper wire.

The detonator consists of a cylinder of gun-metal, containing a hammer supported by a 0·03 inch copper shearing wire and by a safety pin; below the hammer there is a detonating cap of chlorate of potash, fulminate of mercury and sulphide of antimony. The safety pin is withdrawn by the braid at the moment of loading, and ignition is produced by the shock of discharge shearing the wire and setting the hammer back on to the detonating composition.

Three holes in the head of the fuze, protected by thin copper discs and papier-mâché wads, allow the gas to escape. This fuze is used with 13-pr., 40-pr., 6·6-inch and 9-inch R.M.L. guns, and with 40-pr. and 7-inch R.B.L. guns.

Fuze, time, 5 and 9 seconds B.L.—These are similar, with the exception of the detonator, to the 5 and 9 seconds M.L. fuzes.

Remarks on Wood Time Fuzes.—A hook borer is used for boring wood time fuzes: the fuze is held in the borer in the palm of the left hand, its head towards the body; in this position the bit bores through the side hole directly into the composition. All time fuzes are marked in red numerals with the month and year of manufacture, the mark or pattern, and the number of thousands of manufacture; this information being recorded in the practice report, in the event of a fuze failing.

Wood time fuzes will burn nearly 3 per cent. longer for every 1000 feet of altitude; thus at 10,000 feet above sea-level the 15 seconds fuze would burn nearly 20 seconds.

SCALE $\frac{1}{2}$

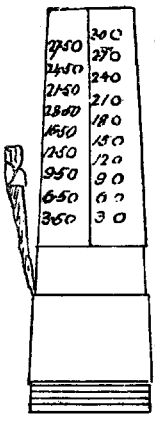
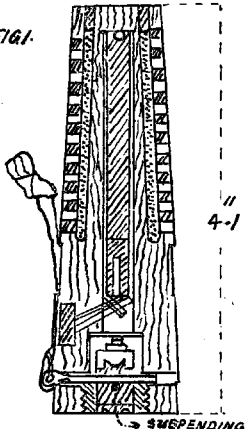
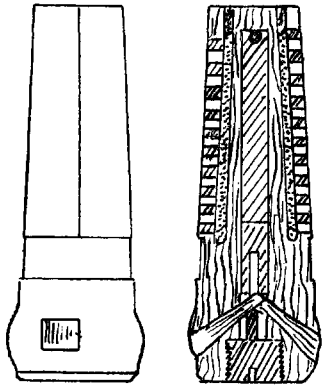


FIG. 1.



15-SECONDS FUZE WITH DETONATOR.

FIG 2.



15-SECONDS M.L. FUZE.

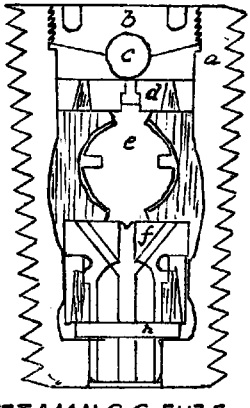


FIG 3.

FULL SIZE.

PETTMAN G.S. FUZE.

Metal Fuzes for Rifled Ordnance B.L. and R.M.L.

Metal fuzes are constructed to act on the graze or impact of a shell or during its flight by employing a time ring of composition; or both time and percussion arrangements are provided in the same fuze. The detonating and cap compositions used in the fuzes consist of fulminate of mercury, chlorate of potash and sulphide of antimony; cap composition containing slightly less fulminate.

The fuzes used in the nose or head of a shell are tapped with a screw thread to suit the general service fuze hole used in all shell, except the B.L. plain fuze, which is dropped in loose.

Base fuzes are screwed into a special bush in the base of shell taking them.

For screwing in fuzes a "Key fuze universal" or "Key base fuze and plug" are used.

The following are the fuzes in the service and their distinguishing numbers, viz:—

Fuze, Percussion—
- Pettman's G.S., No. 5, used up in 7-inch to 12-inch R.M.L.
- Royal Laboratory, No. 7, up to 80-pr. R.M.L.
- Breech-loading plain, No. 2, up to 20-pr. R.B.L.
- Direct action, Marks I., II. and III., No. 3, heavy B.L. and R.M.L.
- Direct-action, Delay, No. 10.
- Small, No. 8, 2·5 inch and 7-pr.
- Direct-action, Impact, No. 13.
- Base, Large, No. 11, 6-inch B.L. and above.
- Base, Medium, No. 12, 12-pr. to 5-inch B.L.
- Base, Armstrong, No. 9, 4·7 inch Q.F.
- Base, Hotchkiss, 3-pr. and 6-pr. Q.F.

Fuze, Time—
- Armstrong "E" No. 22, R.B.L. guns.

Fuze, Time, Sensitive—
- Middle, No. 24, Howitzer star shell.

Fuze, Time and Percussion—
- Middle, No. 54, B.L. guns.
- Short, No. 55, B.L. guns.
- Mark IV., No. 56, 12 and 15-pr. B.L.

Fuze, Percussion, Pettman's G.S. No. 5.—This fuze acts only on impact, and consists of the following parts: body, top plug, plain ball, steady plug, detonating ball, cone plug, lead cup, suspending wire.

The detonating ball, smeared with detonating composition, is enclosed between copper hemispheres covered with silk and gut.

The shock of discharge shears the wire, and the steady plug, detonating ball, and cone plug are set back, the lead cup prevents rebound, and the stem of the cone plug protrudes through the base.

The detonating ball being released, is on impact dashed against the chamber in the fuze, its flash passing down the cone plug into the shell.

Should the detonating ball not be released, the plain ball will act on the composition on the top of the steady plug. Issued 5 in a tin cylinder.

Fuze, Percussion, R.L. No. 7, Marks III.* III. and IV.—This fuze acts on graze or impact, and consists of a body and bottom plug; in the centre of the top is a steel needle, and below a guard and lead pellet with two projections; the pellet contains the detonating cap.

A safety pin passes through the head and supports the guard, being withdrawn at the moment of loading; a small lead pellet closing the hole and preventing the flash on discharge passing into the fuze and causing a premature.

On the shock of discharge the guard sets back, shearing off the two feathers of the pellet, and locking on to the pellet by the projection on the latter wedging into the undercut recess in the guard. On graze or impact the pellet and guard fly forward, driving the cap against the needle and igniting the composition; the flash passes through the pellet into the shell, blowing out the brass disc which closes the fire-hole in the bottom plug.

Fuze, Percussion, B.L. Plain No. 2.—This fuze acts on graze or impact, and in construction and action it is almost similar to the R.L. fuze.

Fuze, Percussion, Direct-Action No. 3, Marks I.* II. and III. —This fuze is not affected in any way by the shock of discharge, and it will act on impact, or on graze if the angle of elevation is about 10 degrees or over.

The body is hollowed out to receive a blowing charge of fine powder, the bottom being closed by a plug.

A plug is screwed into the upper portion of the body, and contains a disc of copper, in the centre of which is a steel needle, below which is the detonating cap.

Marks I.* and II. fuzes have a cap with slots which fit over brass pins in the body, to protect the disc. In Mark III. fuzes a safety plug screws into the head over the needle disc for the same purpose (5788).

The fuze is prepared by removing the cap or plug, and on impact the needle is crushed down on to the detonating composition, which ignites the mealed powder in the conical holes and the fine-grain powder. The cap or plug should not be removed until the moment of loading. Mark I. is obsolete (5572) unless converted to Mark I.* Mark III. fails to act on striking earth, and is used for sea fronts.

Fuze, Percussion, Small, No. 8, Mark I.*—The parts of the fuze are the body, of gun-metal (*a*), detonator pellet (*b*), safety pellet (*e*), ball (*d*), closing pellet, needle, retaining bolt (*g*), safety pin (*h*), base plug (*i*). (7230.)

The detonator pellet, containing a detonator and powder, has a slot cut down its side for the safety pellet and ball to fall into: a screw (*s*) in the body of the fuze projects into a groove down the side of the pellet, and prevents the latter revolving.

The retaining bolt passes through the detonator pellet, as shown in the section at C D.

The safety pellet suspended in the head by a wire, keeps the brass ball in its place between the detonator pellet and the top of the body.

The safety pin, with wire loop attached, passes through a bridge between two slots in the head, and also through the safety pellet. After withdrawal, the hole is closed by the closing pellet of lead and tin.

Action.—The safety pin having been withdrawn, on the shock of discharge the suspending wire is sheared by the safety pellet, which falls into the slot in the detonator pellet, together with the ball. On the rotation of the shell the retaining bolt compresses its spring, leaving the detonator pellet free to move forward against the needle on graze or impact. Marks II. and III. have in addition a spring between the detonating pellet and needle to prevent the former rebounding and causing a premature.

Fuze, Percussion, Direct-Action, Delay, No. 10 (6038).—The fuze is similar to the direct-action fuze, but has a channel of pressed mealed powder communicating with a magazine of M.G.[1] powder. By this arrangement a slight delay in the action of the fuze occurs, enabling a shell to penetrate before acting.

Fuze, Percussion, Direct-Action, Impact, No. 13 (8482).—In this fuze a heavy lead plunger, with a pressure plate level with the top of the fuze, is supported by a pin passing through it into the body of the fuze. On the shell striking, the pressure plate receives the blow, and the plunger, being driven back, shears its supporting pin, the point of the plunger igniting by the blow the F.G. powder placed under it. It was introduced for lyddite shell.

Fuze, Percussion, Base, Large, No. 11, Mark I. (8099).—This fuze is used with all natures of pointed common and Palliser shell, being screwed left-handed into the fuze hole in the base of these shells. On discharge the pressure plate (*p*) is crushed in and the centrifugal bolt (*c*) being released spins outwards on the shell rotating; the needle pellet, being then free to move forward, strikes the detonator on the impact or graze of the shell.

Fuze, Percussion, Base, Medium, No. 12, Mark I. (8100).—This fuze is smaller, but otherwise similar to No. 11 fuze; it is used with 12-pr. to 5-inch shell when fuzed at the base.

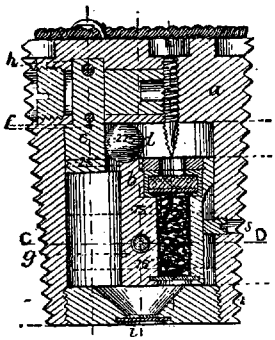
Fuze, Percussion, Base, Armstrong, No. 9 (8515).—The fuze is of E.O.C. manufacture, and is used for cast-iron common shell of 4·7-inch Q.F. for sea service.

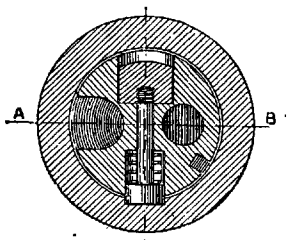
Fuze, Percussion, Base, Hotchkiss, Mark III. (7490).—The fuze is for use with 3 and 6-pr. Q.F. shell; it consists of a metal body containing a detonator or pellet similar to the R.L. fuze; a spring prevents the rebound of the pellet on to the needle until the shell strikes.

Fuze, Time, Armstrong "E," No. 22, Mark III.—This fuze has been in the service for many years. It has a ring of fuze composition which is ignited by a detonating arrangement on the shock of discharge; the fuze is set in a similar manner to the present time and percussion fuzes.

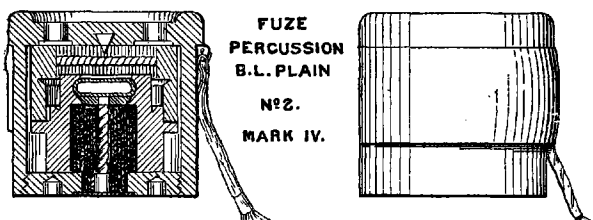
Fuze, Time, Sensitive, Middle, No. 24.—The action of the fuze is as follows: on discharge, and as the shell rotates, the two retaining pellets, which are kept in place by springs, fly outwards, the lighting pellet is released, and, coming in contact with the needle, lights the ring of fuze composition: the latter is graduated from 0 to 30, to read half seconds: the fuze is set by turning the dome and ring and clamping the nut in any required position. The fuze is now only used with howitzer star shell.

Fuze, Time and Percussion, Middle, No. 54.—The parts of the fuze are, the body, composition ring, dome and cap. The percussion arrangement in the lower part of the fuze acts on the shell striking, and is similar to that of the small percussion fuze, and is provided with a safety pin, "P"; the time ring has an annular groove containing the composition, which is lit by a detonating arrangement on its upper side, having a safety pin with the letter T stamped close to it. Opposite the lower arrow on the body of the fuze there is a hole to communicate the flash from the composition ring to the lower part of the fuze, and so to the shell. The dome is graduated up

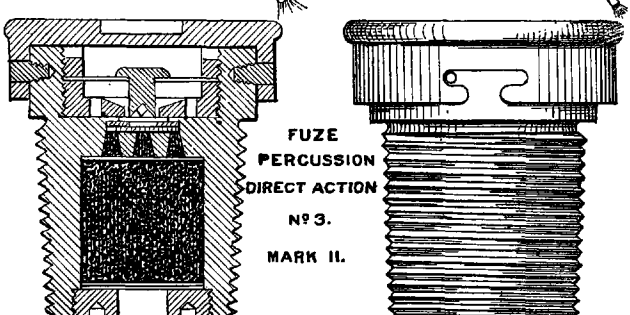




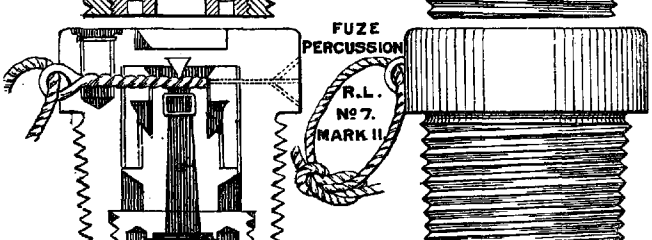
SECTION AT C. D.



FUZE
PERCUSSION
B.L. PLAIN
Nº 2.
MARK IV.



FUZE
PERCUSSION
DIRECT ACTION
Nº 3.
MARK II.



FUZE
PERCUSSION
R.L.
Nº 7.
MARK II.

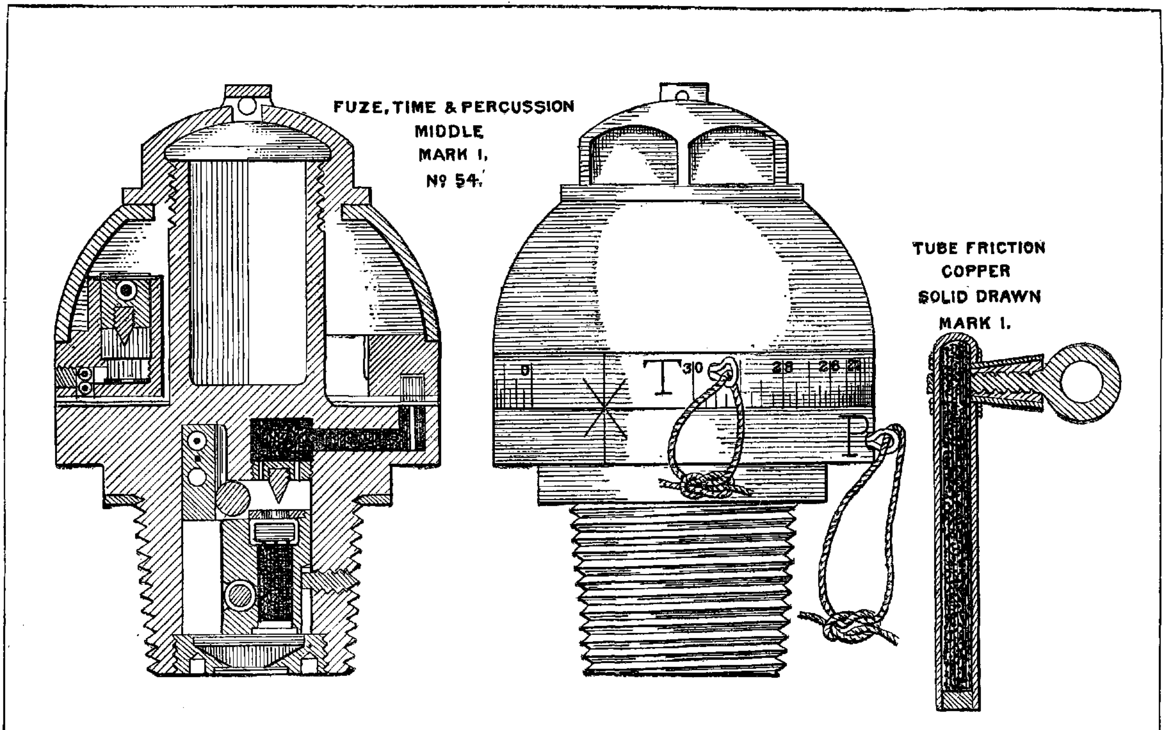


PLATE XIX.

[To face p.

to 30, the full time of burning being about 18 seconds: to set the fuze the top nut is loosened with the universal fuze key, and the required graduation brought opposite the arrow on the body: either or both of the safety pins are removed before loading. The fuze weighs 1 lb. 4 oz.

Fuze, Time and Percussion, Short, No. 55.—This fuze is very similar to No. 54, and burns about 12 seconds when set at its full length, 18. Its weight is 13 oz.

Fuze, Time and Percussion, No. 56, Mark IV. (7716).—This fuze is issued for 12 and 15-pr. B.L. guns. It differs only slightly from No. 55, and burns about 13 seconds at rest.

Tubes.

The tubes used for igniting the charges in all B.L. or R.M.L. ordnance are fired by friction, percussion, or by the passage of an electric current.

Friction Tubes.—With B.L. and R.M.L. ordnance having forward or radial vents, friction tubes are used, made of copper for land service and of quill for the navy. The following are those in the Service:—

Tube, friction, copper, L.S. short		(II.)
,, ,, ,, ,, long		(II.)
,, ,, ,, naval long		(II.)
,, ,, ,, 7-pr.		(II.)
,, ,, ,, solid drawn		(II.)
,, ,, quill, short		(VI.)
,, ,, ,, long		(IV.)
,, ,, "T"		(II.)

Solid-Drawn Tube.—All the copper tubes have been superseded by this tube as regards manufacture for land service. The tube is of copper with a solid head; it is filled with pistol powder, and in Mark II. has a brass ball at the bottom end; its length is 2·1 inches. Near the top a hole is bored, in which is soldered a short nib-piece or cylinder, secured by copper wire. The nib-piece contains a copper friction-bar, roughened on both sides and smeared over with damped detonating composition, consisting of chlorate of potash, sulphide of antimony and ground sulphur; the inner end is slightly turned up, the outer projecting one terminating in a vertical loop; the nib-piece is pinched down on to the friction-bar. The lanyard is passed through its guide and hooked to the vertical eye, and on pulling sharply the friction-bar is drawn out, igniting

the detonating composition and firing the tube. A special solid drawn friction tube is used with blank charges of radially "T" vented field guns: it is 1·6 inches long and has no brass ball.

The *short* tube of 3 inches is used up for guns below 7 inch.

The *long* tube of 5 inches is used for 7-inch R.M.L. and upwards.

The 7-*pr.* tube is 2 inches in length.

The *naval long* tube has a wire loop attached, for a short lanyard hitched to the carriage.

In these tubes the friction-bar is similar to that of the solid drawn tube, but the tubes are driven with mealed powder and pierced with a central hole.

All tubes have a diameter of $\frac{2}{10}$ inch, that of the vents being in all cases $\frac{2}{9}$ inch, except axial vents.

Tubes are packed in tin cylinders which are on no account to be placed in a magazine. A tin tube box holding 100 tubes is used for the service of garrison guns; leather tube pockets being used for field service.

Quill tubes are similar in their action to copper ones: to the head of the tube is fastened a leather loop which is passed over the friction-tube pin screwed into guns for sea service; the loop supports the head of the tube when pulling the lanyard.

Tube, Friction, "*T*," Mark II.—This tube is of brass and for use with cordite charges:* it consists of a solid drawn body screwed into a gun-metal head, containing the friction wire, above which is a hole for the detonating composition: in Mark II. this hole is at the side of the head. The body, filled with pistol powder, has a brass ball which, being driven upwards by the explosion, seals the rush of gas through the vent (7867, 8560).†

Lanyards, Friction Tube, Garrison.

These are designated by numbers.

No. 1 is used for 16-inch, 12·5-inch (II.) and 10·4-inch R.M.L. guns.

No. 2 is for use with guns on disappearing carriages under 9·2 inch.

No. 3 is for use for all B.L. and R.M.L. guns ordinarily.

No. 4 is for use with 17·72-inch R.M.L. guns.

No. 5 is for use with 9·2 and 10-inch on H.P. mountings.

They are all of white line, tarred. No. 3 is 8 feet 8 inches long, and is fitted with a hook at one end and a toggle at the other; near

* With B.L. guns having "T" vents.

† *Tube, Vent-sealing, Electric* "*T*," *Double Wired.*—Externally this tube is similar to the T friction tube, but is furnished with two wire terminals and a wire bridge in the tube; it is used with B.L. howitzers.

[*To face p. 92.*

TUBE, VENT-SEALING, PERCUSSION, P.

FULL SIZE.

Fig. 5.

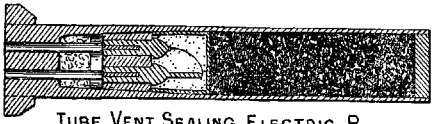
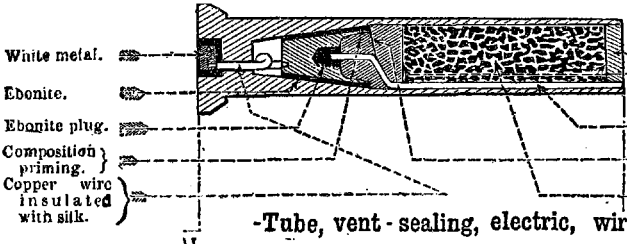
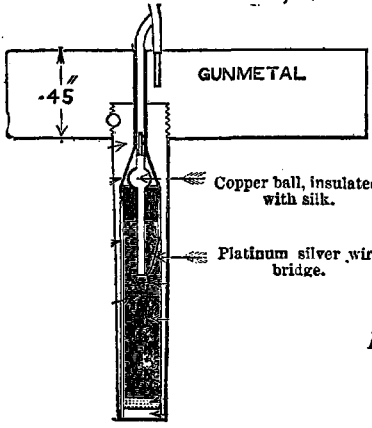


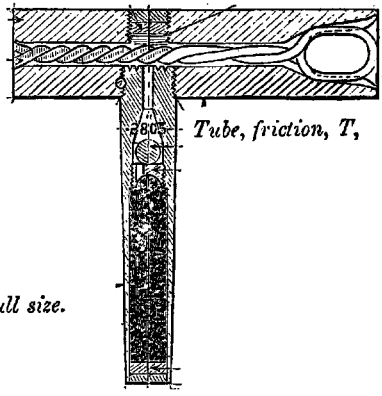
Fig. 6.

TUBE, VENT SEALING. ELECTRIC, P.



-Tube, vent-sealing, electric, wireless, P.

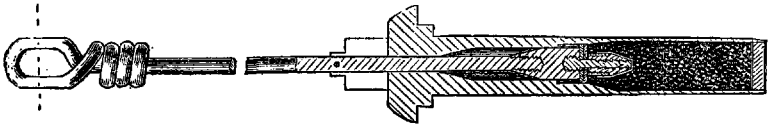




Tube, friction, T,

Full size.

Tube, vent-sealing, electric, T,



TUBE, VENT-SEALING, FRICTION, V. (MARK IV.)

Scale, $\frac{2}{3}$rd full size.

the hook end a piece of line with a loop is spliced for attachment to the lanyard guide. Nos. 1 and 4 have no toggle or spliced piece. No. 1 is 11 feet 10 inches in length, No. 4 is 15 feet, No. 5, 16 feet.

Lanyard, Friction Tube, Siege.—Nos. 1 and 2. No. 1 is used for R.M.L. and R.B.L. siege guns and howitzers, and No. 2 for do. B.L. (6136).

Vent-Sealing Tubes, Friction, Percussion and Electric.

These tubes are used with axially vented B.L. and R.M.L. guns.

For R.M.L. guns having vent heads, being distinguished by the letter V.
For B.L. guns having vent-masking slides, by the letter M.
For B.L. guns having percussion locks, by the letter P.

Tube, Vent-Sealing, Friction V and M.—These are almost similar, but the V pattern has a longer draw wire and a projection on the top of the tube, and the M has the loop of the draw wire screwed on. The tube is of brass, and bored out to receive the wire for attachment to the lanyard, the steel closing-cone, friction bar and charge of powder; the exterior of the body is tapered to fit the vent. At the top of the head there is a small projection fitted with a safety shearing pin which passes through the wire for the lanyard. The inner end of the wire is secured and soldered into a steel cone, and the lower end of the latter is fitted with a copper friction bar. The friction bar passes through a copper disc which is placed in front of a shoulder in the tube, and also through two small oval copper tubes, which are filled with detonating composition and compressed over the bar. The lower portion of the tube is filled with R.F.G. powder, and a cork plug coated with shellac closes the mouth.

On pulling the lanyard attached to the wire, the safety pin is sheared, and the friction bar is drawn through the detonating composition, and the steel cone being forced into the cone at the upper end of the tube, seals all escape of gas.

Tube, Vent-Sealing, Electric V and M are externally similar to the frictional; two insulated copper wires are inserted through the head, and are connected in the tube by a platinum bridge surrounded by priming composition; the passage of the current fuses the bridge and fires the tube.

Tube, Vent-Sealing Percussion.—This tube is used with axially vented B.L. guns having percussion locks. The tube is of solid drawn brass; in its upper part an anvil is screwed over which is a percussion cap; the anvil is bored through its axis, and the tube

is filled with loose powder. On firing, the thin portion of the metal at the top is crushed in by the point of the striker of the percussion lock, and the cap ignited. Mark II. tube has a brass striker passing through its head; Mark III. has the end of the tube closed by a brass ball embedded in sulphur, which clears the vent and also crushes up the prisms, facilitating their ignition (6102). Electric V and friction V are also fitted with this brass ball. Mark I. tubes are obsolete (6626).

Tube, Vent-Sealing Electric P.—The tube is of brass, and externally similar to the percussion tube. The wires, entering the head, pass through plugs of asbestos and ebonite, and are connected by a bridge of platinum wire surrounded by gun-cotton dust and powder; the remaining space is filled with powder. The sealing is effected by the ebonite plug being forced up the cone against the asbestos. The tube has a brass ball, as in Mark III. Percussion. The latest pattern is Mark VII.

Tube, Vent-Sealing, Electric, Wireless, P, Mark I. (8182).—The body is of brass; an ebonite cup, in which is a metal contact piece, fits in a recess in the head; the contact piece is connected by an insulated wire with a brass conical plug, and thence by a platinum wire bridge with a copper wire passing down the tube; the wire bridge is surrounded with priming composition; the brass conical plug acts as a gas check; the tube is filled with pistol powder.

Electric Fuzes, Detonators and Tubes.

Electric fuzes are used for firing gunpowder detonators for gun-cotton charges.

Colour white denotes land service and low tension.
„ black „ land service and high tension.
„ yellow „ naval service and low tension.
„ blue „ submarine.
„ red „ fulminate of mercury.

In low tension, ignition is caused by the passage of the electric current heating a thin wire bridge of iridio-platinum for land service, and platinum silver for sea service. Priming composition of gun-cotton dust and mealed powder surrounds the wire bridge.

In high tension the passage of the current between the terminals causes a spark, which ignites a patch of detonating composition consisting of chlorate of potash, subsulphide of antimony and subsulphide of copper.

The detonators contain a column of fulminate of mercury; the tubes are driven with mealed powder; the fuzes contain loosepowder

which in each case are ignited or detonated by the arrangement in the head.

The annexed Table X. shows those at present in the Service.

All high tension tubes, fuzes and detonators are now obsolete.

Miscellaneous Stores.

Fuze, Safety, Tangye's, consists of lead piping containing the composition covered with jute yarn. It is painted white and burns 70 to 80 yards a second.

Instantaneous Fuze burns 30 yards a second; it contains two or more strands of quick match; it is chiefly used in the navy for firing hand charges from a pistol. It is painted red.

Quick Match is made of cotton wick boiled in a solution of mealed powder and gum. Unenclosed, it burns about 1 yard in 13 seconds; but enclosed in a tube of any kind, it burns almost instantaneously.

Slow Match is made of twisted hemp, boiled in water and wood ashes, or in a solution of water and saltpetre; it burns 1 yard in 8 hours, and is used for lighting portfires, &c.

Common Portfire consists of a cylinder of stout brown paper filled with a composition of mealed powder, saltpetre and sulphur; it burns for 12 or 15 minutes.

Wedge Wads are used with all R.M.L. guns mounted on traversing slides, to prevent the projectile moving to the front in running up; the wad consists of two wooden wedges connected by a piece of cane; the larger size is used with 9-inch guns and upwards, the smaller below 9-inch.

Tin Cups are used with 7-inch R.B.L. guns to secure a gas-tight joint at the end of the bore; the rim of the cup is pressed against the sides of the bore on discharge, and a central hole permits the passage of the flash of the tube. The cups are used in the lower natures of R.B.L. guns at practice only. For the side-closing 40-pr. the tin cup has a rectangular slot cut in its centre.

Vent-Piece Primers are used with 40-pr. and 7-inch R.B.L. guns; the primer consists of a tube of leather paper $2\frac{1}{2}$ inches long, driven with mealed powder, with a central channel; three strands of worsted are attached on the outside to keep the primer in position in the vent. Primers are necessary with these guns, owing to the nature of the vent channels.

Primer, Vent, Cordite, consists of a stick of cordite, size 20, cut 4·75 inches long, for use with vent-sealing tubes without ball, for powder charges only.

TABLE X.—LIST OF ELECTRIC TUBES, FUZES AND DETONATORS.

No.	Description.	Class.	Use.	Service.
8	Detonator (III).	Non-electric.	For demolitions by gun-cotton, with safety fuze	L. S.
9	Do.	Low tension.	For outrigger torpedoes	S. S.
10	Tube.	Do.	Firing guns by electricity	Do.
11	Do.	Do.	Drill purposes only	Do.
12	Detonator.	Do.	Submarine mines	L. S.
13	Do.	Do.	Similar to 9 and 12, for detonating gun-cotton.	L. S.
14	Fuze.	Do.	Similar to 1	L. S.
15	Detonator.	Non-electric.	Use as No. 8	L. S. & S. S.
16	Fuze.	Low tension.	Submarine mines, disconnecting	L. S.
17	Tube.	High tension.	For time guns	L. S.
18	Detonator.	Low tension.	Drill purposes	L. S.
19	Fuze.	Do.	For disconnecting	S. S.
20	Detonator.	Do.	Drill purposes (5407)	L. S.

Proof of Tubes, Fuzes.—A percentage of tubes and fuzes are proved periodically at home and abroad by fire masters, for which purpose a special apparatus is supplied, as described in the Magazine Regulations. No tubes over 10 years old, and in the tropics over 5 years, should be retained on charge for service.

War Rockets.

Rocket, War, 9-pr. and 24-pr.—The following is the principle of construction of these rockets: the head is of cast iron plugged with wood and riveted to the body, which is cut from steel tubing: the rocket composition consists of pellets of saltpetre ground 64·75 parts, sulphur 14·75, and charcoal ground 20·5; each pellet being placed in the rocket case under hydraulic pressure. The base of the rocket is closed by a wrought-iron ring, in which the tail-piece and steel safety cap are screwed. The tail-piece contains three conical vents which are cut away on one side, so that the gas of the burning composition on issuing meets with resistance on one side only, and thus rotation is given to the rocket; the pressure of the gas against the head gives forward motion; a conical hole being bored through the composition, gas is quickly generated. The tail-piece and vents are protected by the steel safety cap, which is removed before firing.

24-pr. rockets are issued to each unit of a siege train; rockets are also used in bush warfare.

For firing, a trough made of sheet iron is used, being supported at its rear end on legs of wrought-iron tubing: two short ones opening right and left, and a longer one extending to the front beneath the trough. On the front leg a bar, which is connected with the trough, slides, so that elevation up to 15° with the 9-pr., and 25° with the 24-pr. can be given. The mean range at 15° is about 1500 yards, but the range and direction of war rockets cannot be depended on.

Use of Gun-Cotton for Disabling Guns.

Description.—The operation of disabling guns by gun-cotton, when required, is carried out by the artilleryman as follows:—

In the case of heavy guns, when time is immaterial, the vent is plugged up and the gun up-ended. The insulated wires from the firing battery are inserted in a detonator, and the latter is then placed in the hole in a 1-oz. primer of dry gun-cotton, no force being used. The dry primer with detonator is then inserted in

the perforation in a 1-lb. slab of gun-cotton, either wet or dry; this, with another 1-lb. slab, is placed in a waterproof bag, choked with twine and plastered with indiarubber solution. The bag is then lowered into the bore, which is filled up with water. The operators after retiring to a safe distance connect up the wires with the binding screws of the exploder, and by turning the handle rapidly explode the charge.

With siege or field guns, and when time is of importance, a 1-lb. slab of gun-cotton containing the dry primer and detonator is tied on the chase of the gun with twine; Safety fuze is used in this case to fire the charge. With 64-pr. guns and upwards, two slabs of gun-cotton would be used. A projectile should be first rammed down the bore to prevent the gun being afterwards used by the enemy for firing any sort of missile in the case of M.L. guns.

A slab or gun-cotton $6\frac{1}{8}'' \times 6\frac{1}{8}'' \times 1\frac{3}{8}''$ in size, and cut into halves, is carried in a leather case, and a proportion are issued to Horse Artillery batteries: a corresponding number of detonators, four in a case, are also carried.

Paper-Proof Shot.—These shot are for use in guns from which service projectiles cannot be fired in peace time without danger to buildings or shipping. The body of the shot is of papier mâché, and is filled with small shot and sawdust; its weight is regulated to give as far as possible service recoils, and it should break up and scatter harmlessly at a short distance from the muzzle.

Nomenclature of Stores.—The letters L, N, C are added to the name of all warlike stores to denote whether they are for land or naval service, or common to both.

CHAPTER XI.

B.L. AND R.M.L. FIELD AND SIEGE CARRIAGES.

Field Carriages.—The following pieces are mounted on field travelling carriages, viz :—

B.L. 12-pr., 15-pr., 20-pr. and 30-pr. guns, and 5-inch and 5·4-inch howitzers.
R.B.L. 9-pr., 12-pr. and 20-pr. guns.
R.M.L. 9-pr., 13-pr., 16-pr. and 25-pr. guns.

The carriages are of steel, but were formerly made of wrought iron or wood. Wooden carriages are still used for R.B.L. field guns, and those of wrought iron for 9, 16 and 25-pr. R.M.L. guns : steel being employed for all other field carriages.

A field carriage consists of a trail formed of two side brackets, connected by plates, transoms, collar bolts, and plate portions of the trail eye, according to construction; the other parts being an axle-tree and wheels, and an elevating gear. Firing and travelling brakes may be provided for the wheels, and in some cases a small hydraulic buffer is fitted to lessen the strain on the carriage, the gun then sliding in a cradle on the carriage. Axle-tree boxes are used to contain a few rounds of case and small stores, the lids forming seats for two of the detachment in some field carriages.

A field carriage should be as light as is consistent with the weight and strength required during recoil, and for withstanding the heavy strains set up when travelling over rough ground. The axle-tree and wheels especially are liable to yield, unless of sufficient endurance. Field wheels are 5 feet in diameter, with a 3-inch tire; each wheel weighs 200 lbs., the wheel track being 5 feet 2 inches.

The trail eye formed at the end of the trail is placed over the pintail or hook on the limber when the gun is limbered up; this method of attachment of the gun to the limber being particularly suitable for rough travelling.

A field limber consists of a frame fixed to an axle-tree with field wheels; on the frame are secured the ammunition or limber boxes, one or two being used, the tops of which form seats.

Pole draught has been substituted for that of shafts in limbers and other vehicles, and those which have been altered to pole draught are distinguished by an asterisk after the numeral denoting the Mark.

An Ammunition Wagon consists of a frame with perch mounted on an axle-tree and field wheels; on the frame are secured the ammunition boxes; the eye at the end of the perch is hooked to hook of the limber for travelling.

B.L. Field Carriages.

Carriage, Field, B.L., 12-pr., 6 cwt., Mark I.—This carriage has two side brackets with elevating gear, mounted on an axle-tree. The brackets are of steel plate riveted to steel angle frames, being connected by transoms and by the plate parts of the trail eye; trunnion holes are formed in the upper ends of the brackets. The carriage is provided with firing shoe brakes, a travelling drag shoe, and a traversing handspike.

The limber consists of a frame and ammunition box on an axle-tree and field wheels. The box holds 44 rounds (8204).

Carriage, Field, B.L., 12-pr., Marks I. to III.—Mark I. carriage is of ordinary type, and is for use with 12-pr. of 7-cwt. guns; when issued to field batteries, axle-tree seats are provided (5362).

Mark II. carriage is fitted with an hydraulic buffer and spring. The buffer is fitted to a top carriage, which is pivoted to the axle-tree and supported at the rear by the elevating screw. The gun is attached to a cradle which slides in guides on the top carriage; springs are provided for restoring the gun to its firing position (6029).

Mark III. carriage is similar to Mark II., but with an improved pattern of elevating gear.

Carriage, Field, B.L., 15-pr., Marks I. and II.—Mark I. 15-pr. carriage is converted from the 12-pr. Mark I. carriage, and Mark II. from Marks II. and III. The conversion consists in providing steel shell pockets, tensile stays, double screw elevating gear, and firing brakes (8162).*

Carriage, Field, B.L., 5-inch, Howitzer, Mark I.—In this carriage the howitzer recoils in a cradle, which is provided with an hydraulic buffer and spring for returning the piece to its firing position after recoil; the piston rod being attached to the breech ring. The cradle is supported by trunnions in bearings in the brackets of the carriage. The recoil of the carriage is checked by

* The top carriage can be traversed 4 degrees, independently of the trail, in Mark II., 12 or 15-pr. carriage.

firing shoe brakes. The limber consists of a steel frame and ammunition box, mounted on an axle-tree and field wheels; the lid opens at the back, forming a shelf. The pole of the limber is 12 feet 7 inches in length. The box contains 21 rounds (8203).

R.M.L. AND R.B.L. FIELD CARRIAGES.

Carriage, Field, R.M.L., 13-*pr.*—The carriage is of steel, and consists of brackets riveted to an angle iron frame. Tensile stays connect the axle-tree arms with the trail for horizontal strength. The elevating arc is attached to the cascable of the gun; teeth on its rear edge gearing with a pinion on the same spindle as a worm that is actuated by a hand wheel placed inside the right bracket. Axle-tree seats on six springs are provided, and two case shot with cartridges can be carried in fittings on the brackets.

Carriage, Field, R.M.L., 16-*pr.*—The carriage is of wrought iron, and has two bracket sides connected by transoms, bolts and a trail plate. Each bracket is of plate iron riveted to the outer side of an angle-iron frame; axle tree boxes forming seats are provided.

Carriage, Field, R.B.L., 20-*pr.*—The carriage is of wood, consisting of a solid block trail and two brackets; a wrought-iron axle-tree bed and two wood naved 5-foot wheels. The gun rests in a saddle to which a limited amount of traversing can be given. It would be used for auxiliary or reserve field batteries, or with the movable armament in a fortress when 20-pr. R.B.L. guns are used.

CARRIAGES FOR MOUNTAIN PIECES.

The following R.M.L. pieces are provided with mountain carriages, viz.:—

4-inch jointed howitzer of 600 lbs.; 7-pr. gun of 150 and 200 lbs.; 2·5-inch jointed gun of 400 lbs.; 15-pr. jointed gun of 422 lbs.

Carriage, Mountain, R.M.L., 2·5-*inch.*—This carriage is in most general use; it is of steel and of ordinary construction, with 3-foot wheels.

For the transport of mountain artillery the guns, carriages and wheels are carried on pack saddles on separate mules; the wheels are merely for facilitating the service of the gun in action or when moving over short distances, and limbers are not provided.

Carriages for Siege Artillery Service.

Travelling siege carriages are used with the following pieces, viz.:—

B.L. 4-inch and 5-inch guns as required.

4-inch jointed gun of 25 cwt., and 5·4-inch, 6-inch of 25 and 30-cwt. howitzers.

For the 8-inch B.L. howitzer a siege mounting without wheels is used.

R.M.L. 25-pr. and 40-pr. guns; 6·3-inch, 6·6-inch, 8-inch of 46 and 70-cwt. howitzers.

R.B.L. 40-pr. gun.

All modern siege carriages are of steel, those of older pattern for R.M.L. pieces being of wrought iron. Siege carriages are necessarily of much stronger construction than field, and are only suitable for transporting their pieces over short distances on hard roads, man power, horses, or steam traction engines being used. Pieces weighing 70 cwt. or over would be transported on platform wagons when off roads. In order to equalise the weights on gun and limber wheels, travelling and firing trunnion holes are provided in those carriages specially intended for travelling.

B.L. Siege Carriages.

The following are used with 4 and 5-inch B.L. guns when employed in a siege train.

Carriage, Travelling, B.L., 4-inch, Mark I., and a corresponding pattern for the 5-inch gun.

The carriage is constructed to fire over a 6-foot parapet, and admits of 25 degrees elevation and 5 degrees depression being given to the gun. It is fitted with a tension hydraulic buffer allowing a recoil of 5 feet.

When the gun is in action, the piston-rod is attached to a radial arm, the plug of which fits in the socket of the central pivot plate of the double-decked platform from which the piece is fired; the cylinder of the buffer is secured by connecting bars to loops on the axle-tree arms. When travelling the buffer is raised up to the trail, for which purpose travelling trunnion bearings are provided.

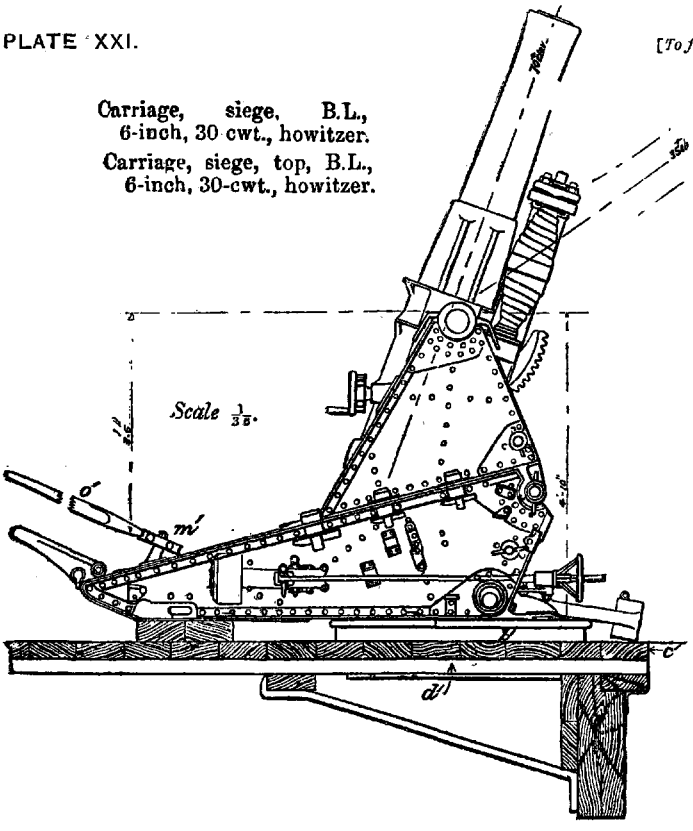
Carriage, Siege, B.L., 6-inch Howitzer, Mark I. and ditto *Top Carriage.*—The carriage when mounted on wheels without the top carriage, permits of a maximum elevation of 35 degrees. For elevations beyond * the wheels are removed and the top carriage

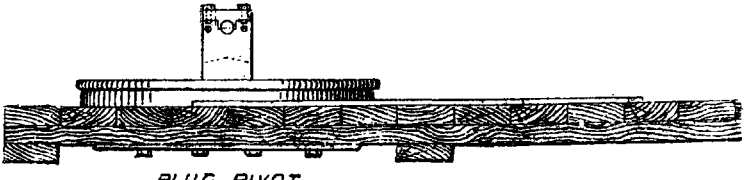
* Up to 70 degrees.

[To face p. 102.

Carriage, siege, B.L., 6-inch, 30 cwt., howitzer.

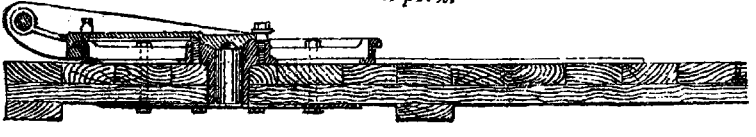
Carriage, siege, top, B.L., 6-inch, 30-cwt., howitzer.





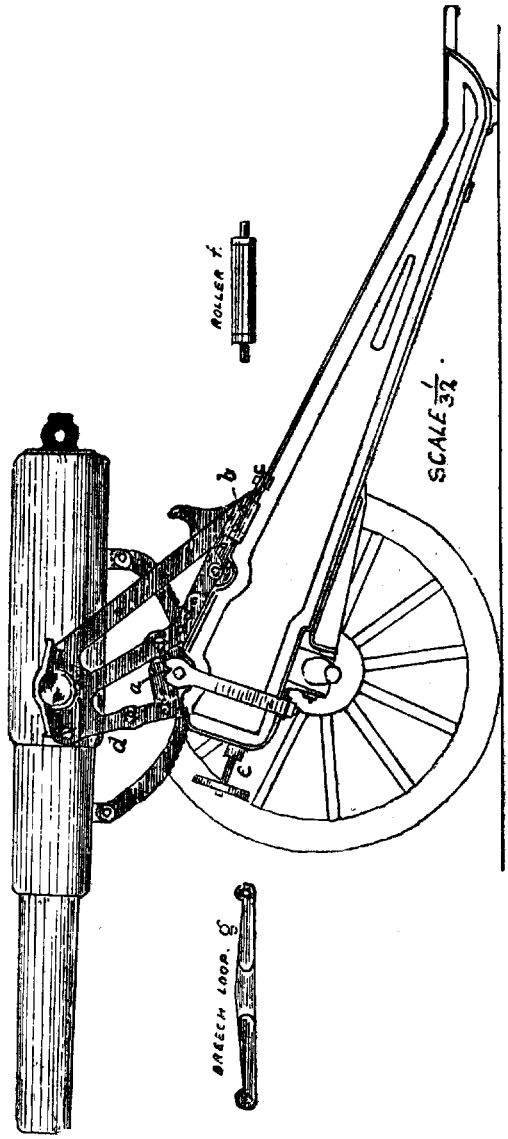
PLUG, PIVOT

1 late pivot.



Platforms, Siege, Double-decked, C. Pivot.

PLATE XXII.


ROLLER F.
SCALE 1/32.
BREECH LOOR. g
40-Pr. OVERBANK TOP FOR TRAVELLING SIEGE CARRIAGE.

fixed, a bed being thus formed. When so used the carriage is secured by a pivot plug to the pivot plate of the double decked platform on which it is fired. The top carriage consists of two brackets formed with bearings for the trunnions of the cradle; the brackets are connected to the carriage by pins and a transom. The cradle in which the howitzer recoils, is fitted with hydraulic buffers having springs to restore the piece to its firing position, the piston rod being attached to the breech ring.

When the carriage is used with wheels, an anchoring buffer is attached to the axle-tree arms and connected with the radial arm of the pivot plate of the double-decked platform (8993).

R.M.L. Siege Carriages.

An Overbank Carriage is used with 25 and 40-pr. R.M.L. guns, and comprises a "top" added to the ordinary siege carriage. The top carriage, having two sets of trunnion holes, is secured to the lower carriage by bolts and clips as shown in diagram; the special fittings required being the top carriage, elevating gear, roller, breech loop for shifting the gun from firing to travelling trunnion holes, and a laying step. The elevating arc is fixed to the gun at either end by plates. By means of the top fitting, the gun can fire over a 5-foot 6-inch parapet. Clerk's platform would be used with "overbank" carriages.

R.M.L. Howitzer Siege Carriages.—The carriages for 8-inch, 6·6-inch, and 6·3-inch R.M.L. howitzers used in a siege train are of ordinary siege pattern, with siege wheels; but, in addition, are fitted with hydraulic buffers for checking recoil: brakes and a roller scotch are provided for use when travelling.

The buffer cylinder, having a ring with trunnions secured near its centre, rests in trunnion bearings, formed on the pivot plug inserted in the socket of the central pivot plate of the double-decked platform. The piston-rod is provided with a link, by which it is shackled to a connecting rod attached to the trail. For travelling, the buffer is disconnected from the pivot and secured under the trail by chains (5431).

Hydro-Pneumatic Carriage for 6·6-inch R.M.L. Gun.—In this carriage, which was used in the siege train, the force of recoil is utilised in bringing the gun down from its firing position above to the loading position below the parapet. The carriage consists of two brackets of steel, a transom, trail eye, solid axle-tree and 6-foot wheels. The gun rests in a crutch on the top of a hollow steel ram, which slides in a cylinder inside of an outer chamber. The cylinder is of gun-metal, with trunnions at its base resting in

bearings in the brackets. At the position of the trunnions the cylinder and chamber are connected by valves. When the gun is in the loading position the ram fills the cylinder, the chamber being filled with compressed air and liquid; on opening the by-pass valve in the right trunnion connecting the chamber and cylinder, the ram is forced upwards and the gun by this means raised to the firing position. On recoil the descending ram forces the liquid back into the outer chamber through the non-return valve in the left trunnion. An air-pump is supplied for charging the chamber and replacing any loss by leakage; the pipe connecting the air-pump is attached when required to a screw valve in the left trunnion; a pressure gauge can also be attached. The gun is further supported by radial arms pivoted to the axle-tree, the arms having long slots to carry the trunnions in either the travelling or firing position. To the upper ends of the radial arms retaining chains are attached.

R.B.L. Siege Carriages.

Travelling Siege Carriage for 40-pr. R.B.L. Side-Closing Gun.—This carriage consists of two brackets, trail eye, axle-tree, and light siege wheels. It is fitted with elevating gear, travelling trunnion holes, a step for laying, and a folding step on the right side for loading purposes. The brackets are frames of angle iron, strengthened by bar and plate iron stays forming lattice girders. Tensile stays connect the axle-tree with the trail. The hand wheel for elevating is on the outside of the right bracket of the carriage. To shift the gun to or from travelling to firing trunnion holes, a wood roller is placed in bearings on the brackets, and tackles attached to loops on the front of the brackets are used. The carriage is constructed to fire over a 6-foot parapet; the weight of the carriage is 25½ cwt.

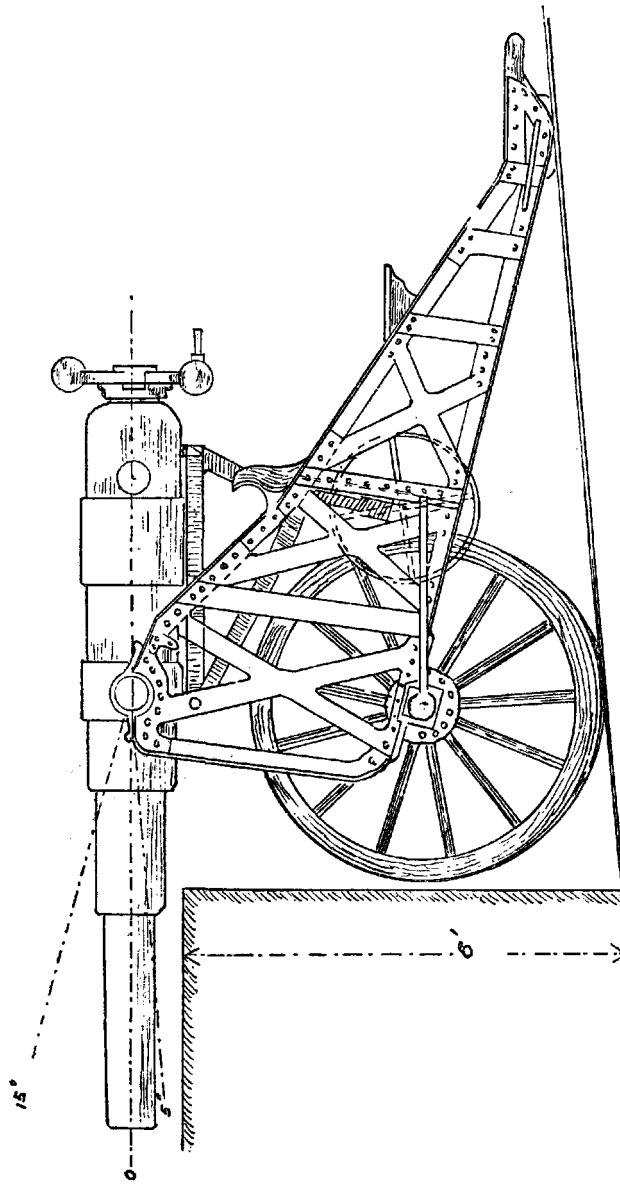
A wood travelling siege carriage of ordinary pattern is also provided for 40-pr. R.B.L. guns not converted to side closing.

Platforms.

Double-Decked Platform.—This platform is used with all B.L. or R.M.L. pieces when mounted on siege carriages fitted with hydraulic buffers.* Two layers of 3-inch fir planks are employed, the lower planks being laid parallel to the line of fire; four transverse planks are placed under the lower layers, and the

* A holdfast of baulks and planks of wood is attached to the under side of the platform at the front when used for 6-inch B.L. howitzers.

[*To face p.* 104.



WROUGHT IRON TRAV.G CARRIAGE FOR 40-PR. R.B.L. SIDE-CLOSING GUN.

layers are connected together by screws. A slope of $\frac{1}{24}$ is given to the platform, which is provided with a pivot plate and plug, and a radial arm; also with steel plates for the wheels and a trail plank. The pivot plate is a circular steel casting having a socket for the central pivot plug,* or for the plug of the radial arms; it is bolted to the platform and to a steel plate underneath. The pivot plug is a steel forging having bearings for the trunnions of the hydraulic buffer. The radial arm is a casting of steel having a short plug to fit the socket of the pivot plate; the piston-rod of hydraulic buffers of B.L. siege carriages is attached to the front end of the arm, and a clip is provided to grip the projecting rim of the pivot plate, and so prevent any "jump" of the carriage (5440).

Clerk's Platform.—This platform consists of two inclined planes of fir made with a slope of 3 degrees, and resting on four transverse transoms. The inclined planes are pivoted to the front transom, and are provided with a riband on their inner sides, and with movable stops in front and rear; traversing bolts are attached at their rear ends. An oak trail plank shod with iron is placed between the planes.

* The pivot plug is used with R.M.L. howitzers, and the radial arm with B.L. guns and howitzers.

CHAPTER XII.

MOUNTINGS OF HEAVY B.L. ORDNANCE.

In the land service disappearing or barbette mountings are provided for 6-inch, 9·2-inch and 10-inch B.L. guns, and upper and lower tier casemate mountings for 12-inch guns; the 8-inch Mark III. gun is mounted on a special Elswick barbette carriage and slide; disappearing mountings are also made for 5-inch guns for India.

On a disappearing mountings the gun recoils to a position below the parapet for loading. It is employed for pieces in works on fairly low sites. Barbette mountings would be used whenever the site is sufficiently elevated to afford protection.

Barbette Mountings.—The following are the barbette mountings in use:—

Carriage, garrison, barbette, B.L.	10-inch	(Mark III.)	(6590).
,,	,,	,,	,,	9·2	,,	,, II.	(6589).
,,	,,	,,	,,	8	,,	,, I.	(5755).
,,	,,	,,	,,	6	,,	,, I. & II.	(8340).
Slide, L, barbette, B.L.	10-inch,	Mark III.					(8901).
,,	,,	,,	9·2	,,	,,	II.	
,,	,,	,,	8	,,	,,	I.	
,,	,,	,,	6	,,	,,	I.	

9·2 and 10-inch Barbette Mountings.—With these mountings the gun fires over an 8-foot parapet at 5 degrees depression and 15 degrees to 17 degrees elevation. Two hydraulic buffers for checking the recoil are used, the recoil allowed being 8 feet; the carriage runs up again automatically on a number of rollers. The buffers can be adjusted to suit varying charges and give a constant pressure. For running back at drill a pump is connected with the buffers.

The slide, consisting of steel girders connected by transoms, revolves on a central hydraulic pivot; a cylinder and ram are fixed on the top of the pivot blocks, so that the weight can be taken off the trucks at either end for facility of traversing. The slide is fitted with elevating and traversing gear and a loading derrick;

a compound armour shield can be used when required. The elevating gear is worked by a hand-wheel on the right, which by suitable gearing actuates the elevating arc fixed by a band to the gun. An elevation indicator shows the degrees of elevation and the range in yards.

Traversing is effected by winch handles, which transmit motion to the front trucks of the slide.

8-inch Barbette Mounting.—This mounting allows of 13 degrees elevation and 5 degrees depression being given to the gun. The carriage is fitted with an hydraulic buffer in tension, permitting of 60 inches recoil; on the left side are fitted the elevating gear, and a stop for holding the carriage in the loading position; a shield is bolted to the front of the side brackets. The slide revolves on a centre pivot which is fixed in a pivot block in the gun floor; the slide consists of two iron girders, connected by front and rear transoms, and a centre beam, the latter forming the pivot plate; a retaining gear on the left side holds the carriage in a loading position.

6-inch B.L. Barbette Mounting.—This mounting allows of 15 degrees elevation and 7 degrees depression to the gun, which fires "en barbette" over a 6-foot parapet, a sunken way being provided. The carriage is fitted with elevating gear, and an adjustable buffer with piston-rod attached to the slide, and live rollers; a steel shield is bolted to the side brackets. The slide is fitted with traversing and retaining gear to hold the carriage in a loading position, and revolves on a live roller ring.

Disappearing Mountings.—The following are the disappearing mountings in use for land service:—

Carriage, garrison, disappearing, B.L.				10-inch,	Mark	I. (6084).
"	"	"	"	9·2 "	"	I. (6085).
"	"	"	"	6 "	"	I. to IV. (5430 & 5912–3–4).

10-inch and 9·2-inch Disappearing Mountings.—These mountings are hydro-pneumatic, and in each case consist of an elevator and cross-head, a lower carriage and an hydro-pneumatic cylinder.

The elevator consists of two steel brackets connected by transoms; one end is pivoted to the front of the under-carriage or slide; the other ends of the brackets being provided with trunnion bearings for the gun. The ram of the hydro-pneumatic cylinder is attached to a cross-head, the arms of which rest in holes about midway in the brackets of the elevator.

The under carriage consists of a circular platform with two girders which support the cylinder, and on the under side of the carriage there is a roller plate resting on live rollers.

The recoil cylinder has an inner and an outer chamber; the ram working in the inner one forces the liquid on recoil into the outer chamber, at the same time compressing the air in the air-chambers. By means of a raising lever the valves are opened when required, and the compressed air then forces the liquid back again under the ram, and so raises the elevator with the gun. The recoil is thus usefully employed in compressing air, and the stored-up force is used to raise the gun from its protected loading position to a firing position over the parapet. Suitable pits are constructed for the mounting.

6-*inch Disappearing Mounting.*—This mounting, of which there are four patterns, is similar in general principles to the above, differing in details only: it is made to suit 6-inch B.L. guns, Marks IV. and V.

Vavasseur Mountings.—The following are provided for certain 6-inch B.L. guns for land service:—

"Carriage, garrison, B.L. 6-inch, Vavasseur, central pivot (Mark I.)."

"Slide, L., B.L. 6-inch, Vavasseur, central pivot (Mark I.)" (6269).

The *carriage* consists of two cast-steel brackets, riveted to a wrought-iron plate. In each bracket there is a trunnion bearing for the gun, and a cylinder for the buffer. The right buffer is in tension, and has its piston-rod fixed to the slide in front; the left buffer is in compression, and has its piston-rod fixed in rear.

The *slide* consists of two steel girders, connected at front and rear. The carriage runs on steel rollers. In each piston there are holes which are open when the gun is run up, and on recoil are gradually closed by means of a rotary valve on the face of each piston, which is turned by studs running in grooves, so that during recoil a constant pressure is kept up. During recoil, the fluid from the left buffer is forced through the pipe into the right buffer to the space left behind the piston-rod, that buffer being in tension. The valve through which it flows is non-return, so that the backward flow of the fluid is prevented; and the other, the by-pass valve, being closed, the fluid remains in the right buffer. The running up of the gun is controlled by means of this by-pass valve.

The elevating gear consists of a shaft, with hand wheel attached to the slide; it transmits motion to the gun through a worm and worm-wheel to a spindle pinion working the spur wheel, which gears into the arc of the gun. On recoil the worm slides along the shaft. The hand wheel and shaft remaining stationary, the gun can be laid and fired at the same time.

12-*inch B.L. Mountings, Land Service.*—The following mountings are in use for certain 12-inch B.L. guns (4866, 5756):—

"Carriage, garrison, B.L. 12-inch (Mark I.)."
"Slide, L., B.L. 12-inch, lower tier."
" " " upper tier."
"Yoke, B.L. 12-inch."

The mounting is used in casemated works. The piston rods of the buffers, in the brackets of the carriage, are attached to the yokes or vertical frames fixed to the gun floor and roof of the casemate. The front of the slide is also bolted to the yokes, which thus take the strain on recoil. An apparatus for withdrawing the breech screw is attached to the right of the slide. The slides for upper and lower tier only differ in the position of the rear trucks. The mounting permits of 7 degrees of elevation and 4 degrees of depression being given to the gun.

CHAPTER XIII.

MOUNTINGS OF HEAVY R.M.L. ORDNANCE.

R.M.L. Gun Mountings.

In casemated works heavy R.M.L. guns are mounted on small port, or casemate, or low casemate carriages, and traversing slides. In open works, either dwarf, Moncrieff, high-angle, or barbette mountings are used.

These are provided as follows:

Casemate, or Dwarf Mountings are for general use for all guns.

Small Port Mountings for 10 and 12·5-inch guns, in a few instances.

Barbette Mountings are specially provided for the 10·4-inch gun.

Low Casemate Mountings are used with 10 and 12·5-inch guns in casemates.

High-Angle Mountings are employed with 9-inch Mark VI. and 10-inch Mark III. high angle fire guns.

Moncrieff Mountings are provided for 7 and 9-inch guns in certain works.

Carriages for R.M.L. Guns.

Carriage, R.M.L., Garrison, Iron, Sliding, Double-Plate, Casemate or Dwarf.—This carriage is in general use with heavy R.M.L. guns in casemates or open works, and is the origin of the designs of iron or steel carriages for R.M.L. or B.L. heavy ordnance.

Description.—The carriage is of double-plate construction, and can be used in either a casemate or dwarf slide. It consists of two side brackets, bottom plate and a front transom, each bracket being formed of plates riveted on either side of a frame; the bottom plate is secured to the bracket and transom.

Angle-iron guides, riveted to the bottom plate, keep the carriage in position between the sides of the slide, and clip plates, bolted to the bottom plate in front, serve to clip the carriage to the slide and prevent "jump," which, in addition to other disadvantages, is liable to cause injury to the piston rod.

The carriage has four gun-metal rollers, which come into play

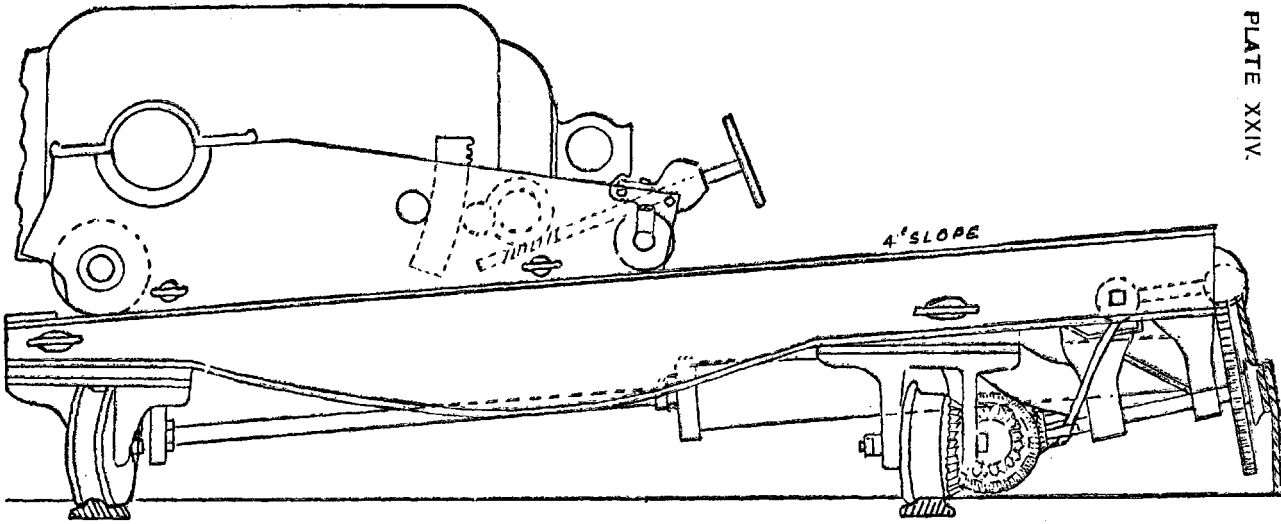


FIG. 1. LOW CASEMATE CARRIAGE AND PLATFORM FOR 10-INCH R.M.L. GUN.

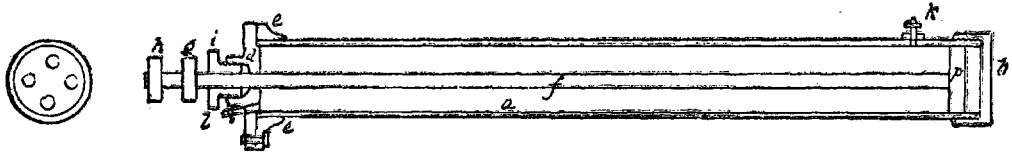


FIG 2. SECTION OF HYDRAULIC BUFFER.

To face p. 110.

in running up or back, but during recoil the carriage itself should bear truly on the slide. The rear rollers are keyed on an eccentric shaft having sockets for iron pointed levers, which are used to raise the rear of the carriage sufficiently to bring the rollers into play. When the levers are removed, pawls on the sockets, applied to "stop plates" on the carriage, keep the latter on "live rollers."

The trunnion bearings in the brackets of the carriage are lined with metal and are provided with cap squares.

Elevating Gear.—Except in the case of 7-inch, a worm-wheel elevating gear is fitted on either side of all carriages. The gear consists of an elevating arc attached to the gun by a pivot plate, the arc having teeth on its rear edge gearing with a pinion on the carriage. On the latter are also fitted a worm, a second pinion and worm shaft with hand wheel. The front edge of the arc bears also against a friction roller in 10 to 12-inch carriages. The gear on either side is actuated by the hand wheels. In the capstan-headed elevating gear used with certain 7-inch carriages elevation is given by iron pointed levers applied in the slots of a small capstan head on the outside of the carriage bracket, small jamming levers being screwed up to clamp the gear.

Fittings for Hydraulic Buffer.—A bracket, having an oval bearing for the piston-rod, is bolted under the front of the bottom plate.

Fittings for Elswick Compressor.—A carriage fitted with this arrangement for limiting recoil has seven plates, supported lengthways on the transom of the carriage in front and behind on a bar across the bottom plate. The plates hang between compressing bars fixed to the slide, the bottom plate being cut away to allow of their passing through. A compressing shaft passes through the right bracket of the carriage, and is furnished with nuts on right and left handed threads, and with rocking levers for compressing the bars. The amount of compression given is regulated by an adjusting shaft acting on the nut on the left side.

Casemate, Low, Carriage.—This carriage differs in having the bottom plate constructed so as to form a well between the sides of the slide in order to allow of elevation up to ordinary angles being given; the low height of the brackets, advantageous in other respects, would otherwise considerably limit the possible elevation.

Carriage of 12·5-inch Gun.—An hydraulic lift is attached inside the left bracket of this carriage for use in bringing the rear rollers into action, the ram being keyed to a crank on the eccentric shaft; a pointer attached to a shaft indicates when the rear of the carriage has been sufficiently raised. The running back, or nipping gear, comprises a shaft across the bottom of the carriage,

carrying two sprocket plates capable of being raised or lowered by a lever outside the carriage. The teeth of the sprocket plates when lowered engage with two endless chains running the length of the slide, and further supported by brackets fixed under the carriage; the chains are set in motion and the carriage run back by means of winch handles. For limiting recoil a tension hydraulic buffer is used, the cylinder being attached to the carriage and the piston rod to the slide.

Small Port Carriage.—This pattern of carriage is specially used with 10 and 12·5-inch guns when mounted behind small ports or casemated works. The feature of the carriage is that means are provided for varying the height of the trunnions, in order that all ordinary angles of elevation may be given to the gun without the chase coming in contact with the upper edge of the port. To effect this, vertical slots are cut in the brackets of the carriage, in which the trunnion bearings slide, an hydraulic lift being placed under the trunnion ring to raise or lower the gun as desired; screw lifts in addition are used under each trunnion to remove the weight of the gun from the hydraulic lift when firing.

Slides for R.M.L. Guns.

The wrought-iron traversing slides used with the beforementioned casemate and dwarf carriage are the *Slide, R.M.L., Casemate* and the *Slide, R.M.L., Dwarf*, with *A, B or C Pivots.*

Casemate Slide.—This slide consists of two slides of girder iron, with two or more transoms, and a top plate bolted over the front of the sides; also of two bottom plates, two truck plates, four flanged feet and trucks, and a diagonal stay of 1-inch plate, formed of a centre piece to which four arms are welded. The slide is 15 feet long, with a slope of four degrees, and has an iron packing piece placed between the rear truck plate and sides.

Buffer stops, formed of alternate rings of felt and steel, are fixed to the front of the slide for the carriage in running up, and also two rear stops for the recoil.

Eyebolts are bolted on either side, in front and rear, for use when tackles are required, and a movable platform-board is placed across the rear of the slide.

Hand posts and sighting steps are provided for the layer when using the vertical sighting blades of sights when laying on moving objects.

A pointer, sliding in a bracket, is attached to the right rear of slides for use with a graduated traversing arc on the gun-floor.

Fittings for the Hydraulic Buffer.—A bearing plate for the front of the buffer is bolted across the slide, and two holding-

down bands also support the cylinder, being bolted to the bearing plate and bottom plate in rear.

Hydraulic Buffer.—The cylinder or tube of the buffer is of steel or iron, its ends being closed by a cap and cover; the piston rod passes through the latter, a tight joint being secured by a packing gland. The other or front end of the piston rod which passes through the bracket under the carriage is attached by nuts on the rod in front and rear of the oval hole; thus the carriage on the recoil forces the piston back.

The piston head has four holes, their size being regulated by the force of recoil to be overcome; the greater this force the smaller must be the holes.

The buffer contains about twelve gallons of oil with the piston rod in the cylinder and the carriage run back. The resistance to the passage of oil through the holes in the piston depends on the velocity of the recoil; there is, therefore, but slight resistance in running up.

Fittings for Elswick Compressor.—A slide fitted with this compressor arrangement has six compressor bars suspended in brackets lengthways between the sides, and a tripper, which acts on the compressing shaft on recoil, if necessary, is bolted to the right side.

Traversing Gear.—A slide is fitted with traversing and running-back gear, actuated by two winch handles mounted on either end of a cross shaft parallel to the rear transom, or, in the case of rear traversing slides, by a single handle on a spindle projecting from the rear of the transom. That portion of the gear which acts on the trucks for traversing can be disconnected by means of a clutch pinion when running back only is required; in that case the fall of the running-back tackle is passed round a bollard, which is revolved by the winch handles.

Special Slides.—The casemate slide for 12·5-inch guns is fitted with rack-traversing and chain running-back gear actuated by the usual winch handles.

A slide to suit a "low casemate" carriage is made higher than the ordinary casemate slide to compensate for the low brackets of the carriage.

In 10-inch slides and upwards "fish-bellied" girder sides are used to impart additional strength.

Dwarf R.M.L. Slide.—Dwarf are similar in general construction to casemate slides, but, a greater height being required, the trucks are of larger diameter and additional packing pieces are inserted between the truck plates and sides.

Pivots of Slides.—Pivots of wrought-iron slides are A, C or D. The two latter, which are "actual" pivots, are usually employed

with dwarf slides: with casemate slides an "imaginary" "A" pivot is used, the radial centre of the traversing arc being in front of the mounting.

Racers.—Steel racers are used for the trucks of slides, being laid for an all-round fire with a "C" pivot; with A or D pivots the length of the arc of racer varies according to the possible arc of fire. The position of the pivot governs the curve of the racer.

Graduated Traversing Arc.—A graduated gun-metal arc is set in the gun-floor or emplacement, for use in conjunction with the pointer on the slide. The numbers of the graduations should indicate the true compass bearing of the gun. Graduated arcs are provided for all ordnance mounted on sea fronts.

High-Angle Fire Mountings.

The following are provided for 9 and 10-inch guns when altered for high-angle fire mountings.

1. *Carriage, Garrison, R.M.L., High-Angle, 9-inch,* Marks I. and II.

2. *Carriage, Garrison, R.M.L., High-Angle, 9 and 10-inch,* Mark III.

3. *Carriage, Garrison, R.M.L., 9-inch, 35 degrees,* Mark I., and *Slide L., R.M.L., 9-inch, C pivot, 35 degrees.*

With regard to 1, Mark I. carriage is used with the altered 9-inch Mark VI.B, and Mark II. with 9-inch Mark VI.C.

As regards 2, Mark III. carriage is used with 9-inch Mark VI.A, and 10-inch Mark III. altered guns.

As regards 3, Mark I. carriage is used with the altered 9-inch Mark VI. gun.

Marks I. and II. *Carriages, for 9-inch* Marks VI.B and VI.C.—These carriages are of steel and hydro-pneumatic, and permit of angles of elevation of 30 to 7 degrees being given. Mark I. is a recoil mounting, and consists of an upper and under carriage or slide, two recoil cylinders, elevating and traversing gear, and a loading trolly, the whole mounting revolving on a live-roller ring. The gun is supported by the trunnions in the upper carriage, which slides on the under carriage, the latter being a circular platform with side brackets. The recoil cylinders are in the line of the trunnions and attached by rams to the upper carriage. The air compressed by the force of recoil drives the liquid back after firing and returns the gun to the firing position.

Mark II. is a non-recoil mounting, the gun being mounted in a cradle in which it recoils. The cradle is provided with hydro-pneumatic cylinders. The mounting revolves on six trucks round a central pivot.

Mark III. *Carriage, for* 9-*inch* Mark VI.A *and* 10-*inch* Mark III.—This carriage is of steel and hydro-pneumatic, and is non-recoil, the gun being mounted in a cradle in which it recoils. The carriage consists of the cradle, under carriage, elevating and traversing gear, and is mounted on a live-roller ring.

The cradle has two pairs of hydro-pneumatic cylinders, the rams of which are attached to the gun by brackets, and is supported by trunnions in ball bearings on the brackets of the under carriage. The air compressed by the force of recoil is used to return the gun automatically to its firing position.

The under carriage consists of a circular platform with brackets, a roller path revolving on a live-roller ring being fixed to its under side. The elevating gear is attached to the front of the carriage, and there is an elevation indicator on the left side. Traversing is effected by means of hand-wheels on both sides; bevelled wheels acting on a pinion gearing with a traversing rack contiguous to the racer. The gun is loaded at an angle of 29 degrees elevation, a loading trolly being used.

35 *Degrees Carriage and Slide for* 9-*inch* Mark VI.—This is a recoil mounting, converted from the service pattern of carriage and slide. The truck axle is relieved of all downward pressure on firing by a box girder arrangement with springs. On the latter being compressed the box girder comes into bearing and relieves the trucks.

Special Mountings for Heavy R.M.L. Ordnance.

17·72-*inch R.M.L. Mountings.*—The carriage is of the usual double-plate construction, fitted with an hydraulic elevating press of gun-metal supported by trunnions on brackets in rear of the carriage.

The slide is of the ordinary iron girder construction with a slope of 4 degrees; it is so arranged that on the gun being run up the pivot takes the weight, the trucks being thus easier to traverse. Hydraulic power is used for the service of the gun and mounting, being obtained by an accumulator or weight kept raised by steam power.

16-*inch R.M.L. Mounting.*—The special mounting provided for this gun for land service is for very exceptional use.

10·4-*inch R.M.L. Mounting.*—A barbette mounting is used for the 10·4-inch, which fires over a 7-foot 6-inch parapet.

Moncrieff Mountings.—The following pieces are mounted in certain positions on Moncrieff carriages, viz.: 64-pr. of 58 cwt., 7-inch of 6½ tons, and 9-inch guns. The gun rests in trunnion bearings on one end of an elevator, a counterweight being at the

other, and is raised to the firing position by allowing the counterweight to sink, the force of recoil driving the gun below the parapet to its loading position. Special gun pits are used with the mounting.

Converted Naval Single-plate Carriages and Slides.—The following pieces are occasionally mounted on these converted carriages and slides, viz.: 7-inch of 6½ tons, 8 and 9-inch guns. The mountings are fitted either with an hydraulic buffer or an Elswick compressor.

Mountings for Medium R.M.L. Ordnance.

Iron and Wood Mountings.—The 7-inch of 6½ tons, 80-pr., 64-pr. of 64, 71 and 58 cwt., and 40-pr. of 34 and 35 cwt. R.M.L. guns are provided with "sliding medium" carriages on "traversing medium" slides for certain positions, these mountings being either of wood or iron.

Common Standing Carriage.—This carriage is in use for 64-pr. converted guns, and consists of two brackets of oak or teak, two axle-trees, a transom, and four trucks of cast iron, the front 19 inches and the rear 16 inches in diameter. The carriage has an elevating screw with a ratchet head and lever, a stool bed of iron, and a large and small quoin of sabicu. Allen's recoil brake is used, consisting of an iron-shod wedge in rear of each front truck.

Rear Chock Carriages.—In these carriages a block of oak or sabicu replaces the rear axle-tree and trucks.

Sliding Carriages.—These differ only from standing carriages in having blocks of oak or sabicu in place of front and rear axle-trees and trucks, two 8-inch metal rollers, to facilitate running up, being secured to the front block. An eye and a notch for pawl are fixed to the rear of either bracket for use with running-up truck levers.

Wood Traversing Medium Slides.—These take all natures of sliding medium carriages, wood or iron; they are either dwarf or casemate. The slide is of teak, and consists of two sides with cheeks, three transoms, a head block, four flanges and four trucks. The wooden compressor can be used, consisting of two cheeks, which are pressed against the sides of the slide by a lever working an iron eccentric.

Mountings of R.B.L. Guns.—20-pr., 40-pr. and 7-inch R.B.L. guns are mounted on "sliding medium" carriages of wood and "traversing medium" slides.

The 40-pr. also uses an iron standing carriage, and the 7-inch 82-cwt. gun is occasionally mounted on a Moncrieff carriage.

CHAPTER XIV.

TRANSPORTING CARRIAGES AND MACHINES.

Transporting Carriages.

Drugs.—A drug consists of a platform of oak on a fore and hind carriage having low trucks, and is used for transporting guns up to about 26 tons on hard roads.

Sleighs.—A sleigh consists of two side pieces of oak connected by transoms; it is used in conjunction with rollers for transporting guns up to about 40 tons: a sleigh of lighter construction is made for guns up to 26 tons. Temporary sleighs are also frequently used for moving guns up to 12 tons.

Platform Wagon.—This wagon consists of a fore and hind carriage having a platform fitted over them, and 5-foot wheels. It is constructed to transport weights, either ordnance or stores, up to 3½ tons. A gun is mounted on the wagon by means of a gyn, by parbuckling up the side or front, or by shifting from its carriage to the wagon by rollers. When in position for travelling, the muzzle of the gun is to the front.

Sling Wagon.—This wagon is made of wood or iron. In the former case it is of oak, and consists of a body and limber. The frame of the body is formed of a perch, two sides, two cross-bars, two brackets, and an axle-tree bed. The brackets are short and low, and are bolted one on each side over the axle-tree bed for the support of the windlass. The windlass, of elm, is cylindrical in the centre, with octagonal ends, and has a ratchet arrangement at either end. At the centre of the windlass is a hook, to take an eye formed in the centre of the special gun sling used; and upon the axle-tree bed in front and rear on each side are similar hooks or pins, taking eye splices on the ends of the sling. The sling passes round the trunnions of the gun, on which iron thimbles are placed, the muzzle of the gun being to the rear; the gun is raised by working levers placed in the sockets, the breech being then lashed up to the perch. The stores issued with the wagon are a 5-inch sling of white rope, two iron thimbles, a lashing of 2½-inch tarred rope, two levers, and two pawls; the latter are placed in the mortise holes in the windlass to prevent it from

turning round when limbering up, which is done by bearing down on the levers and lifting the perch. The wagon must be limbered up before the gun is raised.

Mark I. sling wagon (wood) has cast-iron fittings, and is constructed for weights up to 5 tons.

Mark II. has wrought-iron fittings, and can be used for weights not exceeding 6 tons. For the iron sling wagon 7 tons is the maximum weight. The body of the wagon has 7-foot wheels, those of the limber being 5-foot. The wheel track of the wooden wagon is 6 feet 6 inches, that of the iron one being 5 feet 11 inches. A few sling wagons have been constructed to take 12 and also 23-ton guns, but they are retained for use in arsenals.

A 12-ton gun can be transported by two sling wagons, the gun being slung at the breech and half-weight mark.

Sling Cart.—This cart has two long sides which form the shafts; upon these brackets are bolted; a windlass as with the sling wagon is used. The breech of the gun is lashed up to a prypole in rear of the cart. A detachment of 7 numbers are required; the maximum weight a sling cart will transport is $3\frac{1}{4}$ tons; earlier patterns, with cast-iron fittings, will take weights up to 56 cwt. The wheels are $5\frac{1}{2}$ feet in diameter, with a wheel track of 5 feet 9 inches.

Trench Cart.—This cart is used for weights not exceeding one ton; it is painted red.

Hand-Cart.—This is lighter, but otherwise similar to the trench cart; it is constructed to take weights not exceeding 15 cwt., and is painted a lead colour.

Machines.

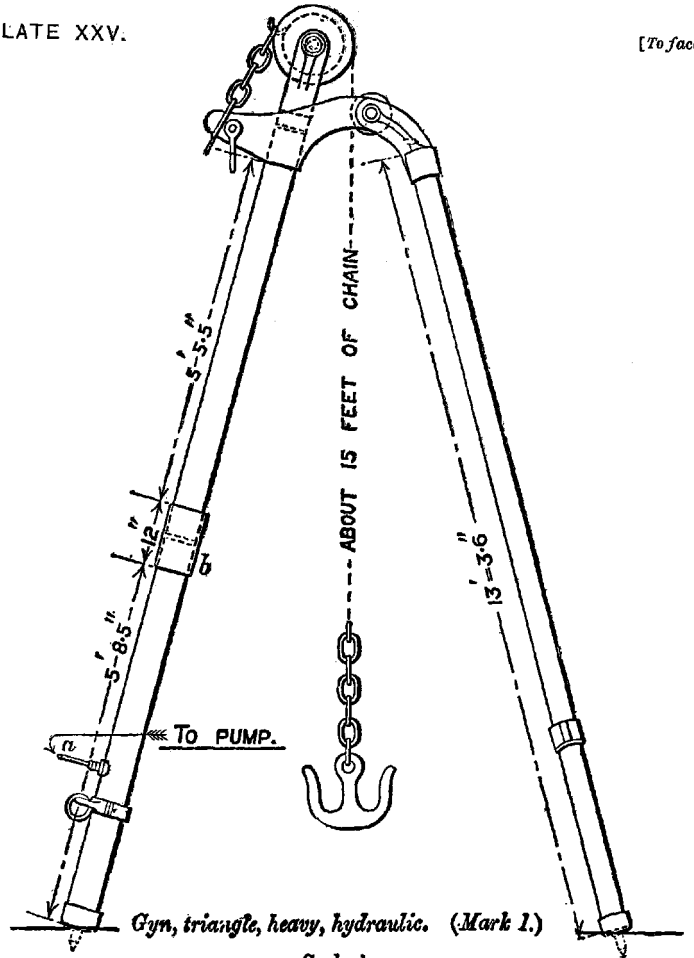
Triangle Gyns.—The following natures are in the Service, viz.:

1. 16 ft. wood to raise 70 cwt., weight of gyn 9 cwt.
2. 18 ft. light, wood (II.) to raise 7 tons, weight of gyn $14\frac{1}{2}$ cwt.
3. 18 ft. heavy, wood „ 12 „ „ „ $26\frac{1}{2}$ „
4. 18 ft. light, iron, or steel „ 7 „ „ „ 16 „
5. 18 ft. heavy, iron, or steel „ 12 „ „ „ 28 „
6. 15 ft. heavy, hydraulic „ 15 „ „ „ 18 „

A gyn consists of two cheeks with cross-bars; a prypole; a windlass; and a shackle with bolt and key. The cheeks are connected by the iron cross-bars, the windlass being first placed in position with its gudgeons in the gudgeon holes of the cheeks.

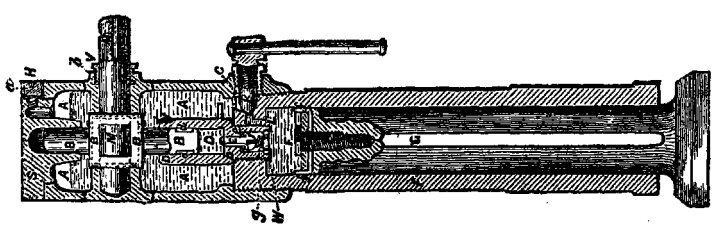
The cheeks and prypole are of fir, or of steel or iron tubing; the shackle and head-bolt are of wrought iron; the upper block of

[*To face p.* 118.



Gyn, triangle, heavy, hydraulic. (*Mark I.*)

Scale $\frac{1}{96}$.



Hydraulic Lifting Jack.

the tackle is hooked to the shackle or head bolt in the forked head of the prypole.

The tackle used with a 16-foot gyn consists of treble and double 10-inch blocks, rove with a 3½-inch fall. With the 18-foot light gyn, two treble 12-inch blocks rove with a 4-inch fall are used, and with the 18-foot heavy, two treble 15-inch blocks with a 5-inch fall.

Wood levers, or winch handles, are used to work the windlass of gyns and so raise the weight; the running end of the fall of the tackle is passed three, four, or five times round the windlass and held on to.

Wooden trucks are provided for the feet to prevent their sinking, the trucks having holes to receive the spikes in the feet.

In taking weights with gyns, the cheeks and prypole should be lashed together at the feet, the cheeks being equidistant from the prypole, and on the same level with it; the more upright the gyn, the greater weight will it bear.

The prypole is the front of the gyn, and the latter should be placed with its head over the centre of gravity of the gun or weight to be raised; the weight should never be hauled to the right or left when suspended; to the front or rear it is permissible to a small extent.

Two gyns may be used, being placed so as to take equal weights, or proportionate weights if of different natures; the cheeks of each being on opposite sides.

Heavy Hydraulic Gyn.—This gyn has a cylinder formed in the upper portion of the prypole, in which works a ram which is pumped up in prolongation of the prypole. On the top of the ram is a sheave over which passes a chain for raising the weight; the standing end of the chain is made fast to a projection on the top of the prypole, and the other end is fitted with a double hook for the sling for the weight. A pump is connected by a pipe to the lower portion of the prypole for working the ram. This gyn will raise 15 tons to a height of 10 feet.

Crab Capstan.—This machine is used for applying power on the running end of a fall when moving or raising weights. It consists of a framework of wood and iron, supporting a barrel in a vertical position. The fall passes round the barrel, which is revolved by capstan bars fitting in mortises in its head, and worked by 12 Nos. walking round, 2 Nos. holding on to the fall. The power gained is 13 to 1. Two tons on the barrel is the maximum strain that may be exerted. The crab is secured to a holdfast.

Iron Crab or *Winch.*—This consists of a barrel supported horizontally in a cast-iron frame bolted to a wooden one: it is pro-

vided with a brake and two winch handles, and can be used with a "slow" or "quick" motion. The winches in the Service are constructed to hoist weights up to 25 and 50 tons.

Lifting Jacks.—Of these there are four kinds. (1) Clerk's screw; (2) Rack and pinion; (3) Haley's screw; (4) Hydraulic.

Clerk's screw jack will lift 5 tons.

The rack-and-pinion jack, 3 tons.

Haley's screw jack, from 2 to 20 tons.

Hydraulic Jacks.—These jacks are constructed to lift weights of from 7½ to 30 tons. They are alike in general form and internal arrangement. The ram with external casing of steel, is screwed to the reservoir, which is of malleable cast iron. To the external casing are attached a wrought-iron claw and lifting handles. At the bottom of the ram are a gun-metal pump and leather packing. The plunger is of steel, and contains the inlet valve; it is connected to a crank on a spindle, supported in bearings, on the sides of the reservoir. The spindle of steel has a socket outside the reservoir for use with a lever. The ram cylinder of steel fits over the ram, and slides between it and the external casing; it is screwed into a malleable iron foot, and is fitted with a leather packing. At the top of the reservoir is an air hole with a wrought-iron screw plug and leather washer; by this the jack can be filled or emptied; the lever handle has a screwdriver formed on one end of it for removing the plug. The fluid used consists of water, methylated spirits, oil, and carbonate of soda.

Action.—The lever acting upon the crank raises and lowers the plunger. By the up stroke a vacuum is created in the pumps, and the pressure of the air in the reservoir forces the fluid past the inlet valve in the plunger; at the down stroke the inlet valve closes, and the outlet opening, the fluid is forced from the pump under the ram, thus raising it with the load. A small hole limits the height of lift by allowing the fluid to escape when the ram leather passes it. To lower the weight the lever is shifted in the socket so as to bring its shoulder upwards, and is then pressed gently down until the plunger touches the valve; by forcing it down to its full extent, the outlet valve opens and allows the fluid in the cylinder to escape through the space round the plunger back to the reservoir.

In older patterns of jacks the internal arrangements are different; in lowering off, the handle is partially drawn off the spindle till it can pass the stop, being then forced down. In still older patterns a screw at the side of the reservoir is eased off to lower the weight. The diagram shows an older pattern of jack.

In raising weights jacks should stand upright, on a hard smooth surface; oak and not fir skids should be used as a base. A thin piece of wood or a little hemp should be placed between the weight and the head or claw of the jack; long strokes of the handle are used, and the weight as it rises should be followed up closely. Great care is required in the use of jacks, and in maintaining them in proper working order. The claws are only intended for half the weight allowed for the top of the cylinders.

CHAPTER XV.

TACKLES, CORDAGE, SKIDDING, ETC.

Blocks.

Blocks are single, double or treble, according to the number of their sheaves, and are termed Admiralty or Bothway's.

An *Admiralty Block* consists of a shell of elm with sheaves of wood or metal revolving on an iron pin supported in the shell; the block is strapped with rope, which attaches a hook at one end to the shell, and a thimble or loop at the other. The shell itself bears the strain, consequently, this nature of block is of weak though light construction; it is principally used with tackles for running back at gun drill.

A *Bothway's Block* consists of a shell of elm, one or more metal sheaves with iron pin, two or more wrought-iron straps according to the number of sheaves, and a shackle with swivel hook and pin.

The smaller natures of blocks have a small shackle with thimble and pin for the attachment of the standing end of the fall; in the larger natures the latter is made fast to a button formed on the head of the pin that supports the sheaves; the sheaves are of phosphor bronze, which is bronze hardened by an admixture of phosphorus, and are stamped with the letters P.B. In a Bothway's block, the sheave pin passes through the straps which take the strain; the shell merely serving to keep the fall in its proper position.

All blocks are measured by the length of their shell in inches; they take a rope having a circumference one-third of their length.

The sizes of Bothway's blocks are 8 to 21 inches; Admiralty blocks 3 to 9 inches.

A *Snatch Block* is an iron-bound single block; on one side the strap opens with a hinge, so that a rope can be passed on to the sheaf at once; it is used for changing the direction of the running end of a tackle. They are 8 to 21 inches in length.

Blocks should be kept clean and lubricated, in order to minimise the loss of power due to friction.

Rope.

Service rope is formed of three strands, each strand being made up of a number of yarns, and each yarn of fibres of hemp.

It is either white or tarred, its size depending on the number of yarns. The size is the circumference of the rope in inches, usually 1 inch to 12 inches. New rope is generally issued in coils containing 113 fathoms.

In order to find the strain that can be put on any rope, divide the square of its actual circumference* in inches by 8; the quotient is the strain it will bear in tons. Thus for 2½-inch—

$$\frac{5}{2} \times \frac{5}{2} \times \frac{20}{8} = 15{\cdot}6 \text{ cwt.}$$

To find the weight of rope, multiply the square of its circumference in inches by its length in fathoms, and divide by 480 for its weight in cwts. Thus for a coil of 113 fathoms of 3-inch rope—

$$\frac{3 \times 3 \times 113}{480} = 2{\cdot}1 \text{ cwt. (weight).}$$

A stranded rope is unreliable, and may be known by one strand projecting.

Rope Slings are used for slinging ordnance or other weights to be raised. A sling is made of white rope and is measured on the double; the circumference of the rope of the sling should not be less than the calibre of a piece that is being raised by it. The nearer the point of suspension is to the upper surface of the gun or other weight, the greater will be the strain on the sling. Slings should never be twisted up.

The sizes of rope slings are:

6-inch, 12 feet 6 inches long, for raising 5-ton guns and under (one tackle).

7-inch, 14 feet 6 inches long, for raising 7-ton guns and under (one tackle).

9-inch, 3 feet long, fitted with thimbles for use at breech when raising 12 to 26-ton guns with two tackles.

9-inch, 7 feet long, fitted with thimbles for use at half-weight mark when raising 12 to 26-ton guns with two tackles.

9-inch, 16 feet long, for raising 12-ton guns with one tackle, and slinging 35 and 38-ton guns at half-weight mark.

12-inch, 4 feet 4 inches long, for use at breech, trunnions or half-weight mark in lifting 35 or 38-ton guns.

Galvanised Iron Wire Rope isused for the guy ropes of sheers for heavy guns, in sizes of 5½ and 6-inch. Wire rope is also used for overhead tackles in casemates.

* Rope that has been in use decreases considerably in circumference.

Chain.

Chain is measured by the diameter of the iron forming the link.

In order to find the safe working load of chain, square the diameter of the iron in eighths of inches and cut off the last figure as a decimal for the strain in tons. Thus in the case of 1-inch chain—

$8^2 = 64$; 6·4 tons is the working strain.

Chain Slings.—A 1-inch link chain sling 12 fathoms long is used for raising 12-ton guns with one tackle.

For the above purpose, and also for raising 18 and 25-ton guns with two tackles, breech and muzzle chain slings with triangular links are used. The breech and muzzle slings are connected by two triangular links and three shackles; they can be so arranged according to the nature of gun that, with the sling over the breech and the muzzle sling over the chase, the triangular link or links will be over the centre of gravity of the gun.

Tackles.

A tackle consists of one or more blocks rove with a fall of rope. The end of the fall made fast is termed the "standing" end; the other end, namely that to which power is applied, the "running" end.

The tackles used in the Service are shown in the diagram.

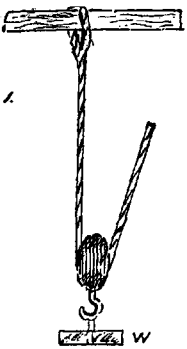
1. A fixed block which gives no mechanical advantage.
2. *Whip:* one single movable block; gain of power, 2 to 1.
3. A *Whip upon Whip:* two movable blocks; gain of power, 4 to 1.
4. *Luff Tackle:* double and single 8-inch blocks, 2½-inch fall; gain of power, 3 or 4 to 1 as used.
5. *Gun Tackle:* two double 8-inch Admiralty blocks, 2½-inch fall; gain of power, 4 or 5 to 1.
6. *Heavy Gun Tackle:* double and treble 9-inch Admiralty blocks, 3-inch fall; 5 or 6 to 1 as used.
7. *Light Gyn Tackle:* the same, but 10-inch Bothway's blocks are used, and a 3½-inch fall for 16-feet gyn.
8. *Gyn Tackle:* two treble 12-inch or 15-inch blocks with a 4-inch or 5-inch fall; power gained, 6 or 7 to 1 as used.*
9. A *Runner Tackle* is one that is applied to the running end the fall of another.

The power gained by any tackle is the sum of all the returns acting directly on the movable block; and in a combination of

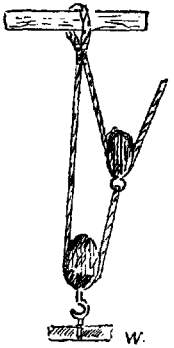
* 18-foot light gyn takes 12-inch blocks.
18-foot heavy gyn „ 15 „

PLATE XXVI.

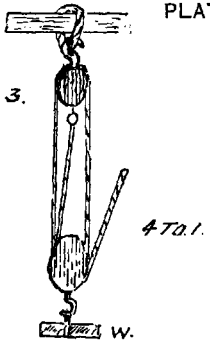
[To face p. 124.



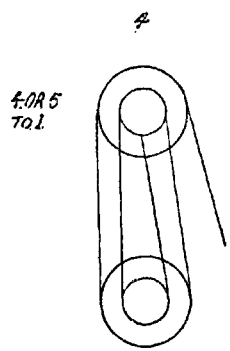
WHIP. 2 TO 1.



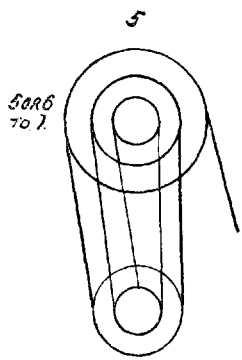
WHIP UPON WHIP. 4 TO 1



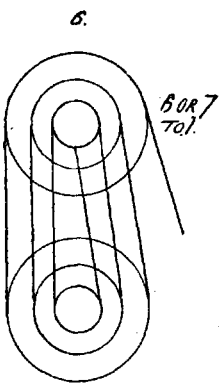
LUFF TACKLE. 3 OR 4 TO 1.



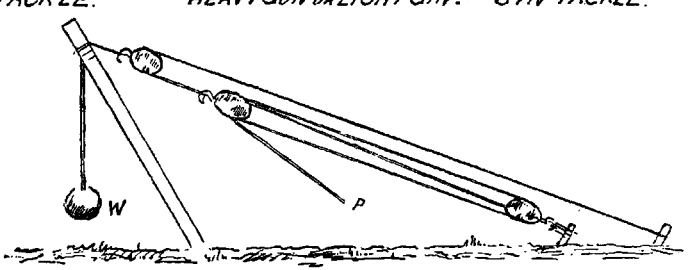
GUN TACKLE.



HEAVY GUN or LIGHT GYN.



GYN TACKLE.



RUNNER TACKLE. 8 TO 1.

tackles the whole power gained is the product of the power gained by each tackle. In consequence of friction and the rigidity of a rope, it is the rule to add $\frac{1}{8}$th of the weight for every sheave in use.

Thus, to find the greatest strain (W) that a luff tackle will take, a part worn fall being used; the double block movable; gain of power, 4 to 1. The total resistance—

$$R = W + \frac{3}{8} W = \frac{11}{8} W.$$

there being three sheaves in use, and—

$$\frac{R}{4} = P = 15 \cdot 6 \text{ cwt.},$$

the maximum strain a $2\frac{1}{2}$-inch rope will take;

$$\therefore 15 \cdot 6 = \frac{\frac{11}{8} W}{4} \text{ and } W = 45 \cdot 38 \text{ cwt.}$$

To find what power (P) must be applied at the running end of the fall of a gyn tackle consisting of two treble 12-inch blocks to raise a weight of 12 tons; power gained, 6 to 1.

Since there are six sheaves, the total resistance is—

$$R = W + \frac{6}{8} W = \frac{14}{8} W = \frac{14}{8} \text{ of } 12 = 21,$$

and

$$\frac{R}{6} = P \text{ (power)};$$

$$\therefore \quad P = \frac{21}{6} = 3\frac{1}{2} \text{ tons.}$$

Handspikes and Levers.

Handspikes are made of ash, 6 or 7 feet long, having the lower end square, ending in a bevel termed the point; the upper portion of a handspike is oval in section, terminating in the small end.

Levers are similar in shape, but the points are not bevelled except in 12 and 14-foot levers; 8, 10, 12, and 14-foot levers are in use in the service.

Levers or handspikes are employed as levers of first or second order.

First order is when the fulcrum is between the power and weight, as in elevating the breech of a gun, using the side of the carriage as a fulcrum.

Second order is when the weight is between the power and the

fulcrum, as in running up a standing carriage, the ground being the fulcrum and the axle of the truck the weight.

The length between the point of application of the power and the fulcrum is the lever (L), that between the weight and the fulcrum the counter lever (C L); and in both cases the power multiplied by the lever is equivalent to the weight multiplied by the counter lever, or $P \times L = W \times C\,L$. Example: a 10-foot lever is applied to raise a weight of 16 cwt., as a lever of first order, with a counter lever of 1 foot; the point of application of power being 1 foot from the small end, to find the power required we have—

$$\left.\begin{array}{r} L = 8 \text{ feet} \\ C\,L = 1 \text{ foot} \\ W = 16 \text{ cwt.} \end{array}\right\} \text{ and } P \times 8 = 16 \times 1. \quad \therefore \quad P = 2 \text{ cwt.}$$

Iron-pointed Levers are of ash with steel or iron points, and are used in running up sliding carriages; they are inserted in sockets, and the small ends being borne down, the rear rollers of the carriage are brought into play.

Iron-shod Levers are short levers shod with iron and used for traversing slides, not fitted with traversing gear; they are applied under the front or rear trucks according to the nature of pivot.

Truck Levers are used for running up wood sliding carriages on traversing slides; they are 7 feet long, having at their points a plate of iron with hook and pawl and metal trucks.

Skidding.

Oak and fir skids for mounting and dismounting ordnance and other purposes in artillery service are in use as follows:

Material.	Length.	Section.
	feet.	inches.
Fir	20	15 × 15
"	20	9 × 9
"	14	8 × 8 & 12 × 12
"	6	12 × 12
"	4	12 × 12
Oak	14	5½ × 5½
"	5	6 × 5
"	3	6 × 9
"	3	6 × 6
"	3	6 × 5
"	3	6 × 3
"	3	5 × 4
"	3	4 × 4
"	11½	15 & 10 × 20
"	10	9 × 15
"	10	8 × 13

English oak, and either Memel, Dantzic or Riga pine are employed.

The weights of one cubic foot being:

English oak	48 lbs.	Dantzic pine	40 lbs.
Memel pine	34 „	Riga pine	41 „

The weight of any skid, beam or spar can thus be easily found.

In order to ascertain the weight that any beam or skid can bear when supported at two points and loaded in the middle, the following formula is used:

$$W = \frac{4\,b\,d^2\,S}{l},$$

where W is the breaking weight in pounds.

b is the breadth or horizontal measurement of skid or beam in inches.

d is its depth or vertical measurement in inches.

l is the distance between points of support in inches.

S is the coefficient, value for fir 1100, for oak 1977.

For selected timber, $\frac{1}{2}$ W is a safe working load, and $\frac{1}{4}$ W for unselected.

Planks are used under skidding on soft ground, or as a roadway for a sleigh, or gun on rollers; and on the top of long skids, when parbuckling heavy guns; in the latter case oak planks would be employed.

TABLE OF SERVICE PLANKS.

Material.	Length.	Width.	Thickness.	
	feet.	inches.	inches.	
Fir	12	9	3	Whole.
„	10	17	3	„
„	5	17	3	Half.
Oak	10	17 & 12	3	Whole.
„	6	12	3	Half.
„	4	12	3	„

Rollers are used for mounting, moving, and shifting ordnance. The following are in the Service:

Material.	Length.	Diameter.	Use.
	feet.	inches.	
Elm	6 and 4	10	Ground rollers.
"	6 and 3	6	"
"	3 and $2\frac{1}{2}$	5	"
Sabicu	14 in., 20 in., 2 ft., $2\frac{1}{2}$ ft., and 3 ft.	5*	Shifting rollers.
Oak	7 and 8	12	For heavy sleighs.

* Also a sabicu roller 2 feet × 8 inches diameter, and a steel roller 8 feet × 8 inches diameter for heavy sleighs.

The weight moves twice as fast as the rollers; friction is reduced, but no mechanical advantage is gained.

There are other special gun rollers used for shifting guns mounted on travelling siege and overbank carriages; a roller being made to suit each particular carriage.

Scotches are made of elm, in three sizes, large, medium, and small; they act as wedges, being placed in front or rear of any weight to prevent movement when required.

Picket Posts are made of ash shod with an iron point and hooped at the head. They are 5 feet 6 feet, and 8 feet long for garrison service, $2\frac{1}{2}$ feet long for field service.

Holdfasts required in artillery service have in many cases to be extemporised; in good holding ground, picket posts driven in answer the purpose, an ordinary arrangement being to drive three, two and one pickets into the ground and lash them, when they will stand a strain of about 2 tons. For heavier strains, pickets in conjunction with a baulk of wood or a gun or beam sunk may be used, as circumstances and the nature of the ground require.

Prisms are blocks of wood 16 inches × 6 inches × 5 inches, bevelled at either end, and are used for various purposes.

FIG. 1.

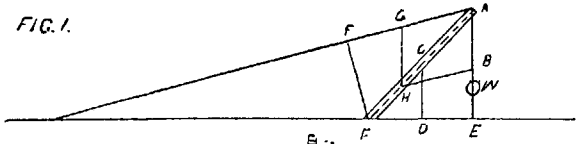
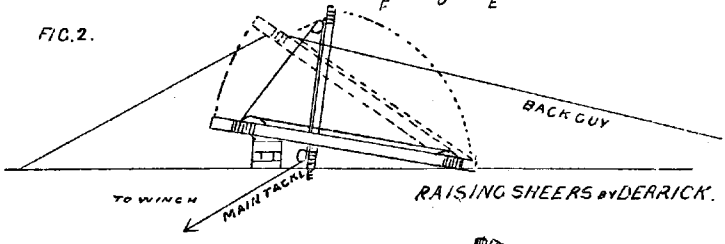
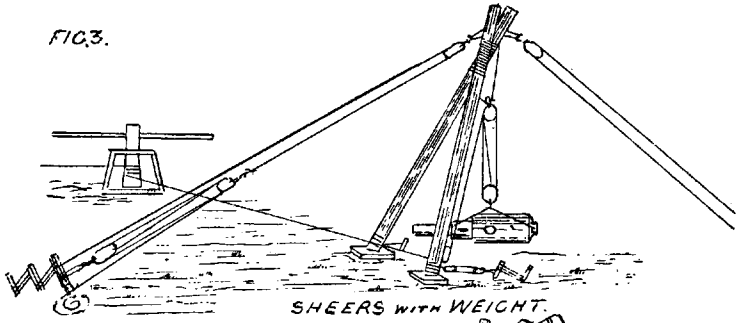


FIG. 2.



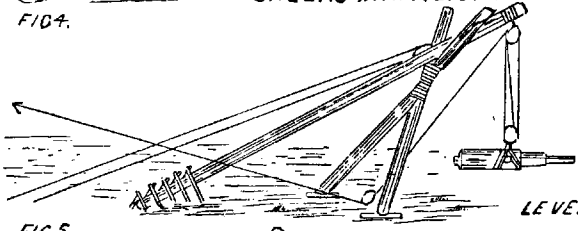
RAISING SHEERS by DERRICK.

FIG. 3.



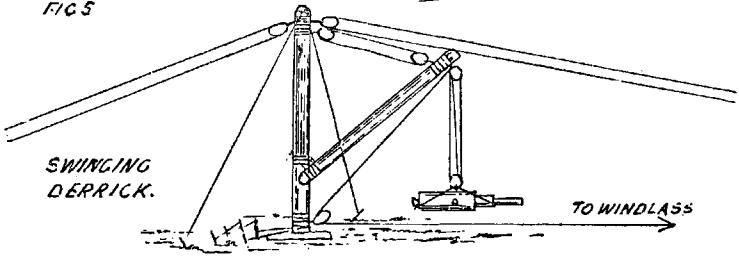
SHEERS WITH WEIGHT.

FIG 4.



LEVER SHEERS.

FIG 5



CHAPTER XVI.

SHEERS, DERRICKS, AND STORES FOR MOUNTING AND DISMOUNTING ORDNANCE.

Sheers.

Spars for sheers are of fir, 30 to 70 feet long, and 11 to 24 inches in diameter, according to the weights they may be required to raise. 40-foot spars, 12 inches in diameter, would be suitable for raising weights up to 5 tons; whilst for 38 or 43-ton guns, 70-foot spars would be used; the stores, cordage, blocks, &c., being proportioned to the size of the spars employed.

Light Sheers.—To rig and raise a pair of sheers to lift 5 tons, 40-foot spars being used; the following is briefly the operation.

Sections consisting of about 4 to 6 numbers each, would be told off for the following, viz.: 1. Head of sheers; 2. Feet of sheers; 3. Fore guy; 4. Back guy; 5. Main tackle, sling for weight, leading block with lashing, stopper, steadying ropes; 6. Crab capstan.

The undermentioned stores would be required.

Rope.—Head lashing, 25 fathoms of 3-inch white rope.

Fore guy, 56 fathoms of 4½-inch tarred rope.

Runner for fore guy, 56 fathoms of 2½-inch tarred rope.

Back guy the same as for fore guy.

Main tackle, one coil of 4-inch white rope.

Blocks, Bothway's.—Two 12-inch single, for fore and back guys.

Two double and two single 8-inch blocks for runners.

Two 12-inch treble blocks, and one 12-inch snatch block for main tackle.

Rope Slings.—One 6-inch sling for main tackle.

Two 5-inch straps for fore and back guy.

One 6-inch sling for slinging the weight.

Crab Capstan complete for taking in the main fall.

Other stores required are: three luff tackles; shoes for feet of spars; light lashings; handspikes; picket posts; mauls; selvagees; intrenching tools; spun yarn.

Splay.—The splay of the spars should be one-third of their length, measured to the crutch. The distance of the holdfasts for

guys should be twice the length of the spars to the crutch, measured from the foot of the spars.

Holdfasts.—For the guys and capstan holdfasts, three, two, and one pickets (5-foot) would be suitable, and for the feet of the spars two and one pickets placed 5 feet from them.

Head Lashing.—The lashing is made fast to the lower spar above the crutch with a timber hitch; a sufficient number of returns are then taken round both spars towards the feet; the end being led round this lashing and both spars from front to rear or from rear to front; this tends to keep the spars together, the end is then made fast on the upper spar with a clove hitch. The straps into which the single blocks of the guys are hooked are each placed with one turn round the spar farthest from the guy and then round both spars to prevent the latter from separating. The sling for the main tackle is put on single or double; if single, it is passed up one spar and between both at the top; if on the double, it is passed over the top between the spars.

Guys.—A 12-inch single block is hooked to each guy strap, the guy rope is passed through the block, and a hawser bend made into which the runner tackle is hooked. The guy should be three times the length of the spars from the hawser bend to the front or rear holdfast. The standing end of the guy is made fast to the holdfast, the remainder being coiled down. By the guy the power gained is 2 to 1, and 4 to 1 by the runner tackle, consisting of a luff tackle, or in all 8 to 1.

Crab Capstan.—This should be placed nearly in line with the feet of the sheers, and the leading block through which the fall of the main tackle passes to the capstan is lashed to the foot of the farthest spar.

Foot Tackles.—These comprise one luff tackle between the feet of the spars to prevent their splaying outwards, and a luff tackle to each foot, which is eased off as the feet come into the shoes in raising the sheers.

Raising the Sheers.—Sheers of this nature would be probably raised by the back guy by means of a 14-foot lever, its small end being made fast to the back guy between the hawser bend and the block at head of sheers; a 2½-inch rope is clove-hitched over the small end of the lever, forming side guys for it, which are kept outside of the back guy, and are made fast each to a single picket, being let go altogether as the lever comes vertical when the sheers are rising. The butt of the lever is towards the feet of the sheers, and rests against a skid held by pickets (see diagram).

To prevent blocks twisting, and so causing friction, handspikes are lashed to them.

The numbers man the fall of the runner tackle of the back guy,

and so raise the lever and afterwards the sheers until nearly vertical.

Moving to the front.—The sheers, having been raised with the back guy, would have to be moved to the front to the edge of the pier or other position, which is done as follows: a spar is lashed across the sheer spars close to the ground, and planks placed lengthways under each foot: tackles are used to haul the feet forwards, assisting with handspikes applied under the cross spar; the back guy being eased off and the fore guy taken in at the same time, the head of the sheers being slightly inclined inwards.

Raising the Weight.—To raise the weight the fall of the main tackle is taken in by the crab capstan. Seven or eight degrees of heel should be allowed for the stretch of the back guy when the weight is taken. As a rule the heel of the sheers from the vertical should not exceed 20 degrees, which will exert a strain on the back guy of half the weight of the sheers in addition to the weight raised.

Raising by Gyn.—Light sheers may be also raised by using the cheeks of a gyn as a crutch for the back guy, the standing end of which passes over the head bolt of the gyn, the running end being manned.

Raising by Derrick.—Another method is to raise the sheers by means of a derrick or single spar about 25 feet long for 40-foot sheers. The derrick is placed with its head midway between the feet, its butt towards the head of the sheers. A leading block is made fast to the head and foot of the derrick, which is provided with side and back guys. The lower block of the main tackle is made fast to one of the sheer spars, and the running end is passed from the upper block of the main tackle to the leading block at the head of the derrick, and through the leading block at its foot to the capstan. The numbers walk round on the capstan and so raise the derrick: when nearly perpendicular its back guy is made fast, and by continuing to walk round on the capstan the sheers will rise till high enough to be under the control of the back guy, by which the remainder of the raising is completed: the derrick is then lowered by walking back on the capstan.

Heavy Sheers.—In the case of 60 or 70-foot spars, two main tackles would be employed, and the sheers would be raised by a derrick 40 feet in length, the latter being raised by the cheeks of a gyn. 18-inch or 21-inch blocks and 6 or 7-inch falls would be required for the main tackles. As a rule such sheers would be fitted with a head bolt and furnished with wire guys and short chains for suspending the upper blocks of the main tackles. If not so fitted the head lashing would consist of 4-inch white rope. One or two guys of 6-inch rope rove through a single and double

18-inch Bothway's block would be used: power gained by each guy, 4 to 1. The running end of each guy would lead straight away from the double or movable block to the barrel of a 5-ton crab by which the guys would be worked.

Strain on back Guy.—To find the strain on the back guy of sheers and the thrust on spars.

First method, tension of guy × F P = W × F E + weight of spars × F D.

Second method by construction.

If A B = W + weight of main fall + ½ weight of spars, then A G represents strain on back guy, A H represents thrust on spars; B H being drawn parallel to A P and H G parallel to A B.

Lever Sheers would only be used for weights not exceeding 5 tons, and when a back guy only can be fixed. A crutch of the desired height is prepared in the ordinary way. A long spar is laid on this, having the upper block of the main tackle made fast to its projecting end: the foot of the long spar is firmly butted in the ground to prevent it slipping back; it is kept from rising by being weighted or lashed to pickets driven in across it.

Gyn Sheers.—The prypole is lengthened by lashing a 20-foot spar to it, which thus forms a strut in place of a fore guy. To the end of the lengthened prypole, the movable blocks of two tackles are fixed, the standing to the feet of the cheeks: by these side tackles the gyn sheers are raised and the amount of heel regulated. The weight raised must be under that for which the gyn is intended.

Derricks are used for lighter weights than sheers, and also to raise sheers themselves. When a weight is taken it can be swung through a considerable space and then lowered. A derrick may be either "standing" or "swinging." The former is used when a direct lift or slight lateral play is required; the latter when the weight to be raised is lighter and more lateral play is required. In addition to the stores for ordinary sheers, two side guys are required: the derrick is raised by the same means as light sheers.

In the case of a swinging derrick a swinging spar is prepared with a main tackle and connected to the upright by the main tackle of the standing derrick; its butt is lashed to the upright or supported in a shoe at the foot of the derrick.

Mounting, Dismounting, and Moving Ordnance, Carriages, &c.

Mounting and dismounting Guns up to 5 tons.—Guns on siege carriages or standing carriages may be mounted and dismounted by

1. Gyn, or Gibraltar gyn if in a casemate.
2. Parbuckling up and down the side by 14-foot skids.
3. Up and down the rear either with or without rollers, and may be shifted from carriage to carriage by plank and rollers, and by slewing. These exercises are useful for teaching the elements of mounting and dismounting ordnance and the handling of the stores.

Guns up to 5 tons mounted on traversing slides would be mounted and dismounted by a gyn or by watered skids up and down the rear, or if in a casemate provided with overhead bolts, by means of tackles.

Mounting and dismounting Guns above 7 tons.—Such pieces can be mounted or dismounted by a light 18-foot gyn, or by watered skids up and down the rear, if not exceeding 7 tons; up to 12 tons by an 18-foot heavy gyn, using the chain sling; or dismounted by watered skids down the rear, but not mounted by the latter method.

The following methods are applicable to guns of the above weights in an open battery.

1. One gyn (guns up to 12 tons).
2. Two gyns, provided the weight on either gyn is not exceeded: the cheeks of the gyns are placed on opposite sides.
3. One gyn at the breech, and building up with skidding under the muzzle in the port if the carriage and slide are to be removed; or building up on the slide if the carriage only is to be taken away.
4. Gyn at the breech, and jack or levers at the muzzle. The gun is run up or back, and cross-built skidding is arranged in front of the trunnions. When the gun is high enough the carriage is run back and dismounted if necessary. The gun is then lowered, breech and muzzle alternately, by the gyn at the breech and jack or levers at the muzzle, on to skidding across the slide, from which it is parbuckled on to a sleigh or as required; the carriage and slide being run to the rear on a temporary sleigh.
5. Jacks alone, should no gyn be available. In this case the muzzle portion of the gun rests on a long skid supported at either end, so as to leave about 7 feet in the clear. An oak beam is lashed to the breech, a jack being placed under either end, leaving,

as before, 7 feet clear between the supporting piles of skidding. By this means the carriage and slide can be removed to the rear. It requires less skidding to support the muzzle end of the gun on the slide, and to parbuckle the gun off the slide, removing the carriage and slide separately. Screw jacks are preferable to hydraulic jacks for the final operation, as they admit of the weight being traversed, and it is easier to keep the beam horizontal.

In casemated works heavy guns would be mounted and dismounted as follows:

1. In casemates fitted with overhead bolts by means of special tackles. In this case strong iron shackles replace the swivel hooks and shackles of Service blocks: for the breech 18-inch treble blocks are used, suitable in the case of the lower block for attachment to the breech, and in the upper block to a loop fixed in the arch of the casemate. A 3-inch short wire rope with eyes is used under the muzzle, and two muzzle tackles are employed, consisting each of two treble 12-inch blocks having shackles in place of hooks; the object of the special blocks in both cases being to obtain increased lift. The falls of all three tackles are led away to iron crabs through leading blocks if necessary.

2. By overhead tackles at breech and jack at the muzzle. This operation is similar to that in which the gyn is used at breech and jack at the muzzle, with the exception that in place of the gyn the breech tackle is worked by an iron crab. In mounting, the slide would be brought into the casemate and the gun parbuckled on to it; and in dismounting, the gun would be lowered on to the slide after the carriage is removed.

In certain casemates having three overhead bolts, the slide may be brought into the casemate inverted on rollers, and turned over with a gyn tackle at the centre overhead bolt, then traversed to a flank. The carriage is then brought in on rollers, raised by tackles and lowered on to the slide, both being then traversed to a flank. The gun and sleigh are then brought in and the former raised by the tackles; the carriage and slide are traversed under, and the gun is lowered into the trunnion holes.

3. By jacks alone, as described for guns in open batteries.

Box Beam Apparatus.—This is used in casemates of not less height than 9 feet 6 inches for mounting or dismounting 38-ton guns.

The box beam of wrought iron, is about 11 feet long, being curved in the centre to clear the gun; it weighs 17½ cwt.

Two main screws, 5 feet long and 3 inches in diameter, pass through holes near the ends of the beam, and are secured by nuts to washer plates and bolts fixed permanently into the roof of the casemate. The gun is suspended by bent bolts which pass round

the trunnion studs and through the ends of the beam. The box beam, with the gun attached to it, is raised or lowered by means of hydraulic jacks placed under its ends.

The gun having been brought into the casemate the box beam would be placed over it, and the main screws attached to the roof and beam by nuts; the gun is then attached to the box beam by the loop bolts. 30-ton jacks are used at either end to raise the beam and gun, the beam being followed up by the spherical nuts on its under surface: the beam and gun thus raised up to the roof are left suspended; the carriage is then raised up to the gun, and the slide brought in underneath; the carriage being then lowered into position, and afterwards the gun into its trunnion holes by means of the jacks.

In casemates 12 feet in height or in open batteries the box beam is suspended from a wooden frame instead of from the roof. The frame consists of two pairs of teak posts 9 feet 6 inches in length and 10 inches × 10 inches in section, their feet standing on wrought-iron bases, and their heads fitted with wrought-iron caps. Two cross beams, 10 inches × 10 inches in section, are bolted into the wrought-iron caps at the head of the uprights and secured by diagonal stays. The entire weight of the gun and beams is taken by the wrought-iron caps on the head of the teak posts, the cross beam serving to steady the uprights.

Apparatus, Lifting Guns, Hydraulic (7646).—This has been introduced for mounting and dismounting 10-inch guns and upwards in casemated works.

Moving Guns.—The methods of moving guns on land are:

1. By railway trolly: suitable for all guns.
2. By drug: up to 25 tons: over hard surfaces.
3. By sling wagon or cart: guns up to 5 tons by sling wagon; to 12 tons by two sling wagons; to 3 tons by sling cart.
4. By platform wagon: up to 3 or 4 tons.
5. By sleigh: all guns, but temporary sleighs only suitable up to about 12 tons.
6. By rollers: all guns.
7. By travelling carriages (siege) on hard roads.
8. By parbuckling: all guns.

Mounting Carriages.—Sliding carriages can be mounted and dismounted up or down the rear of their slides by means of long skids placed between the carriage and sides of the slide, the carriage being further raised to the requisite height by planks placed across. The rear rollers are brought into play and the carriage hauled up or down the rear; the long skids being allowed to tip as the carriage comes over the rear of the slide. They can also be mounted and dismounted up or down the sides of their slides

by placing oak pieces under each bracket, lashing them together, and forming an incline of two long skids.

They can be transported, by drugs; on their slides; on a temporary sleigh; or on long skids by bringing the rear rollers into play.

Moving Slides, &c.—Slides are moved by transporting axle and dilly, by temporary sleigh, or upside down on rollers; up to 12 tons a gun may be transported on its slide, in case of necessity.

With a temporary sleigh long skids are placed fore and aft, inside or outside the trucks as may be most convenient, and fir planks or 6-foot skids are placed across, to raise the slide clear of the rollers or ground; short rollers being used on each side when the skids are placed outside.

When a slide is fitted with traversing gear it is more convenient to turn it upside down by means of a gyn or overhead tackle, or by tackles and levers. The slide can then be conveniently moved on rollers.

The artilleryman who has been thoroughly trained in the foregoing operations, which are fully detailed in the Garrison Artillery Drill Book, finds no difficulty in dealing in a similar manner with any type of ordnance or mounting, whether of old or new design; modifying his arrangements to suit each particular case. The fixed armaments in our fortresses at home and abroad which have in the course of years been moved and mounted by garrison artillerymen, testify to their readiness of resource in this respect when trained.

CHAPTER XVII.

LAYING ORDNANCE, RANGE AND POSITION FINDING.

THE systems of fighting a "fire" or "battery command," or a group of guns down to a single gun, have been elaborated in recent years, and are detailed in the service drill book. The following remarks are for the purpose of affording a clearer comprehension of the use of the matériel and stores employed in connection with the operations.

Laying Ordnance.—Guns on fixed mountings are laid on an object by the following methods:

1. By sights which are used for giving both elevation and direction to the piece; this method is termed "Case I."
2. By sights for line or direction only: elevation being given by a clinometer, hydro-clinometer, elevation indicator, or by an index plate and reader; this method is termed "Case II."
3. By the methods used in 2 as regards elevation; line or direction being given by means of a graduated traversing arc with a pointer attached to the slide; this method being termed "Case III."
4. By automatic sights when the operation of lining the sights on the object by elevating or depressing the piece at the same time places the latter at the correct elevation for any range, the sights in this case acting as a range-finder. It is an application of Case I.

By the first and second methods the range is found by a Depression Range-Finding Instrument, and range dials * are used to communicate it to the gun-groups when the distance of the latter from the instrument requires it. The first method would only be made use of for fixed or slowly moving objects; in the second case the piece, elevated as required, is fired as the object moves across the vertical sighting-blade of the sight.

By the third method the range and bearing of the target are found by a position-finder from a P.F. cell, and are electrically

* Or electric dials.

communicated to the gun-group, the gun being fired from the P.F. cell. The ranges and bearings are predicted ones, the position the ship will occupy when the gun is fired being given. This system possesses the advantages, that the commander has a more complete control over his guns and of the selection of his target, and can fire when the front of the gun is obscured by smoke; also errors due to the gun layer are eliminated. The general adoption of smokeless powder, however, will take away the one great advantage of the position-finder.

With quick-firing guns time does not permit of the range being found and communicated, and of the necessary adjustment of sights or means of giving elevation, and the application of position-finding would be obviously impossible; consequently it has hitherto been a matter of some difficulty to combine accuracy with rapidity of fire in the pieces. The adoption, however, of automatic sights will go far towards a full development of their power. With heavy guns the time necessarily taken in loading affords an opportunity of finding the range, &c., by the service methods with more accuracy probably than is likely to be obtained with an automatic sight.

Range and Position-Finding Instruments.

Depression Range-Finding Instrument.—In coast batteries sufficiently elevated above the sea level Colonel Watkin's D.R.F. instrument is used.

For heights of	25 feet	to	60 feet,	Mark I. D.
„	80 „	„	100 „	Mark II.
„	50 „	„	125 „	Mark II. A.
„	100 „	„	150 „	Mark II. B.
„	240 „	„	600 „	Mark II. C.

The principle of the instrument consists in the solution of a right-angled triangle (in which the perpendicular, or height of battery, is known) by measuring one of its angles, that is the angle of depression to the object, the corresponding distance of the instrument to the object being automatically recorded on a drum. For great accuracy the height of the instrument should be considerable and the range not excessive.

The instrument when in use is carefully levelled on a base-plate fixed on a permanent pillar. The height of the base-plate above mean tide level is of course known, but the instrument is further adjusted by means of one or more datum points of known ranges along the shore.

The difference between the range found from the position of the range-finder and the actual range from the centre of a gun-

group will vary according to the training of the guns or bearing of the object, and this correction, termed "displacement," is made at the guns.

Position-Finding Instrument.—For each of the more important gun-groups in a fortified area a position-finder would be installed. This consists of an "apparatus, position-finding," the invention of Colonel Watkin, C.B., R.A., and comprises a position-finder suitable for use up to 8000 yards or 10,000 yards, as required (8061 and 8321). Special cells are constructed for the apparatus, and well-trained operators are required for its use (see 'Handbook of Position-Finding Instruments').

Nolan Range-Finder.—The instrument is issued for siege artillery service, and is also suitable for coast batteries on the sea level, where a vertical base cannot be used. The horizontal base which is employed necessitates the measurement of two angles, and the instrument is only suitable for use in finding the ranges of fixed objects.

Mekometer, Artillery.—A right and left instrument are issued to horse, field and mountain batteries, for measuring ranges of fixed or moving objects, a base of 25 or 30 yards being used. A "mekometer cavalry and infantry" is used in these services, similar in principle to the artillery mekometer (7995).

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